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Security for Contracts.

The requisite security given for the work to be performed under a contract has, like many other things, changed greatly with the increase in magnitude of contract works. Formerly when the interests covered by a contract were relatively small, and when the character and capacity of contractors, especially for large works, were less well established than at present, it was only reasonable that measures of security for the faithful and efficient performance of the work should be rather drastic. In many cases there were comparatively few contractors of wide experience for the simple reason that the opportunities for acquiring such experience were few and far between. The fact that engineers as well as owners were themselves without sufficiently extended experience to specify altogether wisely as to either materials or procedures led to the unloading upon contractors of some responsibilities they should not have carried. Under such circumstances it is not a matter of surprise that many crudely qualified, not to say unscrupulous, contractors frequently bid upon works of all magnitude. As these bidders were on the same apparent footing with responsible and experienced contractors, the degree of security required was necessarily that which would assure the owner against the most hazardous tender which might be offered.

It was then both natural and necessary that a contractor should be subject to the retention of a considerable percentage during the progress of his contract, as well as to the additional obligation of furnishing a bond for the satisfactory performance of his work. This reserve for contracts not of great magnitude has usually been from 15 to 20 per cent. of the amount of the progress estimates, although latterly, especially in contracts for municipal work in the city of New York, 10 per cent. has been the ruling provision. These parts of progress estimates retained for the satisfactory performance of work are cumulative. If the contract is a large one, therefore, extending over a comparatively long period of time, a large amount of money evidently accumulates to the credit of the contractor so long as his work is satisfactorily performed, but of which he can receive no immediate benefit. This not only denies him the use of the money, but usually forces him into an expensive interest account which runs until the final payment after the completion of his contract. While such a condition is, to some extent, a necessary incident of contract work it constitutes a burden upon the contractor for which obviously the owner ultimately pays, but which should not be increased beyond the limits necessary for reasonable security.

It is an illusion to suppose that owners do not in the long run have to bear the expense resulting from this feature of contract work. Interest account is too well defined and bears too heavily upon the contractor not to become an element of estimated cost in every efficiently conducted contractor's business. This feature of the matter is of special significance in connection with municipal contracts, where the slow methods of payment resulting from much official red tape are so well known by every bidder. It is therefore not only unwise for the municipal or other owners to make this burden of security heavier than necessary, from the point of view of added cost, but it has the further defect of making contracts for many important works exceedingly unattractive to the best class of contractors, who find no difficulty in securing much less burdensome business from other large but not municipal corporations.

This whole question of the security of contracts needs thorough reconsideration, especially on the part of municipal corporations contemplating the extraordinarily large public works construction now in view in a number of the greater cities of this country. In the case of these works it is manifestly reasonable and businesslike to require the execution of a bond in suitable amount from every contractor undertaking such work. Public interests demand this, and the conditions surrounding public works are such that it is both reasonable and necessary. On the other hand, it does not seem either reasonable or necessary that, in addition to such a bond, a cumulative retained percentage throughout the entire progress of the contract work should be required. A certain amount of retention from progress estimates probably cannot be avoided, but that it should be cumulative to the end of the work is quite another matter. In the case of construction carried over a period of years, the retained amount becomes excessively large before the work is half done, and it is not necessary for the security of the contract that such unreasonable amounts should be withheld from an efficient contractor. It has been thought in some quarters that the usual retention of perhaps 10 per cent. of progress estimates might be allowed to accumulate until a sum sufficient for reasonable security may be reached, and that all subsequent estimates should be paid in full. This certainly appears adequate when the added security of a satisfactory bond exists. It is difficult to show why a municipal or other corporation will not be sufficiently guarded against even an inefficient or unscrupulous contractor by such a procedure. At any rate, it is clear that either such a fixed limit for cumulative retained percentages or something equivalent to it should be adopted, not only to relieve efficient contractors of unreasonable burdens, but also to reduce the costs of work to municipal bodies and bring the administration of municipal construction into a more reasonable and businesslike condition.

The Engineer in the Field.

The latest events in the Panama Canal situation throw an interesting light on some of the mental processes of the public in relation to engineering works. A certain gentleman of most undoubted and distinguished capacity is quoted as saying that he wanted to go down to posterity as the man who built the Panama Canal. It is surely a worthy ambition, but in how far can it be justified in relation to such a work? As things stand to-day it is the rarest exception when any single man can be credited with the full honor of a great engineering achievement. One man there was, De Lesseps, who nearly forty years ago, could properly be credited with the work of cutting the first of the world's great canals. He was a pioneer who showed the way to results, and though he failed later at Panama, his failure was chargeable not to lack of capacity, but to the unscrupulous grafters who financed the scheme. It would be idle to-day to ascribe the honor of possible success at Panama to any one man or group of men, and this is true of most large engineering works. Their scope is too big to be within the grasp of any single person. They require the faithful and intelligent co-operation of many men in many different directions, and this very fact has stood in the way of success over and over again. There can be no esprit du corps when one man arrogates to himself the glory of the work and wishes to pose as the supreme spirit of the enterprise. This is where the Corps of Engineers, U. S. A., will have the advantage at Panama. The esprit du corps is already established and will not fail them.

In any great undertaking the ultimate responsibility for success or failure rests not with the sleek promotor who "places" the securities, nor with the big panjandrum who makes suggestions and puts his O. K. on the details that others have worked out, but with the faithful, hardworking constructing engineers, who month after month, stand by and watch over the great masses of unskilled labor that handle great masses of material. Theirs it is to get around early in the morning and see that nothing goes wrong, to chase up shipments of material, to rectify mistakes and to clear up difficulties. Time and again it happens that the powers at the other end of the line blunder or are careless, so that necessary things fail to arrive. Then it is up to the field engineer to hustle about and make those blunders good. If the men who work in the field could

jointly contribute their experiences, they would make a library full of instances where the success of the plan depended absolutely on the work carried out as a last resort at the scene of action. Our modern method of industrial development, with a few highly paid men in so-called executive positions won by financial rather than technical ability, and thousands of cheap subordinates with no hope of advancement, fairly courts blunders in the output. It is the constructing engineer who must repair damages, replace failures and extemporize for omissions. If he succeeds he is put on a tougher job for reward; if he fails he is sacked, and every incompetent at the home office is ready to shuffle off the responsibility for bad work on the fellow a thousand miles away who is expected to get results anyhow. This is no fancy picture; it is just the sort of thing that goes on every day all over the country, and it is one of the weak spots in our industrial system.

Now and then will be found a concern in which responsible subordinates get full and prompt appreciation. They are in truth the mainstay of any technical business, of any business, in fact. With respect to engineers in particular, the strongest executive powers are called forth by active work in the field. It is just as necessary to the development of a resourceful and valuable man as is sea service to the efficiency of a naval officer. The office engineer ought periodically to come into touch at first hand with the real thing, and no man should be allowed to stay in the field so constantly as to lose his close view of the office end of his business. Specialization often goes too far, and we know of no better instance than the tendency to develop special office engineers and special field constructors. And the worst of it is that it seems a part of a particularly short-sighted and dangerous policy that seeks to hinder any one man from getting too close a knowledge of the whole business, lest he become too valuable. Time used to be, for example, when a railroad president was a man who had worked up perhaps from a chainman and had at his finger tips all the details of construction and management. To-day, to judge from the sinister revelations now being placed before the public, he is required to be an expert in placing and manipulating shady securities. It is this change of view and purpose, perhaps, which should be charged with some of the responsibility for the terrific casuality list annually rolled up on American railroads. It is time to call a halt in extreme specialization in practical engineering. Give the field engineer a fair show for advancement and make the drafting room engineer get out and handle his own product now and then. A change in policy may cost a little more in salaries, but it will pay for itself in results.

The Legal Protection of Industrial Secrets.

Everybody with much experience in manufacturing different classes of products, particularly those prepared by chemical processes, is aware that neither the patent law nor the protection afforded by registered trade-marks is of much use in quite a variety of cases in assuring to the inventor a proper return for his time and thought spent in devising some improvement. It is generally fairly easy to prove an infringement of a patent on some appliance manufactured for sale, but it is almost impossible to prove an infringement on a process or an appliance used in a manufacturing establishment where strict secrecy is maintained. The infringer is very likely to keep his infringement an undiscoverable secret. This is a condition that affects such a variety of industries that special importance attaches to a discussion of it which Mr. Frederick P. Fish, president of the American Telephone & Telegraph Co., recently presented before the American Society of Mechanical Engineers. The author's position as the executive head of a company deeply interested in patents and as a lawyer who has studied carefully the various aspects of legal protection of inventions and other intangible property, makes the address one of exceptional value to engineers and manufacturers. It is particularly timely because there is at present a manifest wide-spread interest in the protection of industrial secrets, brought about by the extraordinary development in manufacturing during the last ten years. This development has reached the stage at which the aid of other laws than those of patents and trademarks is required, and the interest in Mr. Fish's address lies mainly in his clear statement of what those laws are and the reasons on which they are based.

It will be evident on reflection that there is just the same reason for protecting a trade secret from inequitable appropriation that there is for giving letters patent or for the registration of a trademark. The cardinal principle of the government's attitude toward industrial development is the encouragement of the individual to risk an effort which will be productive of advantage to the community. No one is likely to face the trouble, anxiety and cost of experimenting and testing new ideas, which are sure to fail in the majority of cases with the chance of great loss, unless he can look forward to a substantial reward if he succeeds. Mr. Fish elaborated this statement in much detail, but it is hardly necessary to discuss his interesting account of the historical development of the decision that, as a practical matter, there can be no greater stimulus to the individual to do the best that is in him toward building up the industry with which he is connected, than the certainty that he may secure and maintain for his own use that which he has acquired fairly and honestly according to the standards of his time. At times objections are raised to this proposition, due to public disapproval of temporary tendencies in current industrial methods, but the general view is that the better and more useful the workman, the more he should have of the rewards of life. We know that the entire community profits by the deserved success of any individual in it, and we feel instinctively that if the efforts of individuals are attacked or discouraged, all will suffer. It is on this account that the law will protect the man who has honestly acquired a trade secret against its dishonest attainment by another.

A trade secret Mr. Fish defines as some method of manipulating or combining materials, or of directing the forces of nature, or of organizing machinery, or the details of a business resulting from original thought, which is of trade value to the person who has the thought or the right to apply it, and is kept by him a secret that he may get from it a personal advantage not to be shared directly by his competitors. Under no standard of law or ethics is the owner of such a secret under an obligation to disclose it to anybody or to use it. It is to the advantage of the public that he should use it, however, and as the patent laws will not protect all classes of inventions, it is incumbent on the law to encourage the use of those trade secrets which it cannot guard by letters patent. The only encouragement it can offer is to help the owners of these secrets to maintain their secrecy, and this it gives in no uncertain terms.

It is of course inequitable to protect by law something that is not a real secret. Any unpatented innovation that once becomes known is public property, and rightfully so. All the law can do is to insist that those who are bound by contract or by good faith to aid in keeping a secret must be faithful to this obligation. It does not protect a secret against discovery by fair and honest means. It only enables it to be utilized, for the good of the possessor and the public, without danger of betrayal by those who learn the secret in confidence while it is being operated as a secret, and who can only betray it by what the law regards as a breach of honesty and fair dealing. This view of the law Mr. Fish illustrated by reference to a number of decisions in this country and England which make it absolutely clear that the law requires those who receive a trade secret in confidence must keep it. It follows that there is also a remedy against those who have received a disclosure of the secret from persons guilty of a breach of confidence or of contract in imparting it, unless they themselves were both entirely honest in the matter and protected by the equities of the situation. It is possible that with wider experience in the application of this legal protection as now given by the highest courts, conditions may arise which will prove the necessity for modifying the character of this protection in some respects. It may be questioned, however, whether the general principle that people under obligation to keep a trade secret must preserve it will ever be altered, and if any change takes place it is likely to be toward increased severity toward those who divulge such secrets and those who receive them.

The Classification of Excavation.

If the reports of decisions of courts of final jurisdiction are safe guides concerning the character of the litigation arising over construction work there is no single feature of contracting as now carried on which gives the lawyers so much to do as the classification of excavation. Several important cases based on this subject have been reviewed in The Engineering Record, and a year or so ago it suggested that the subject was so important that a thorough discussion of it by one of the leading engineering or railway societies was in order. The topic was presented before the American Society of Civil Engineers on Wednesday of this week in a valuable paper by Mr. W. F. Dennis, of which a brief abstract appears elsewhere in this issue, and it is very desirable that those engineers and contractors who were unable to take part in the oral discussion should communicate their views to the Society for publication later. Simple as it may seem, there is no engineering work which calls for better technical judgment and greater judicial ability than the determination of the classification of some kinds of excavation for purposes of payment. There are some materials difficult to excavate by a method for which a low unit price is paid and easy to remove by one for which the unit price is higher. Naturally enough the contractor wishes to employ the more profitable method, and just as naturally the railroad or other party for which the construction is performed desires to save as much expense as possible. In most contracts the engineer is the judge of the method to be followed, and the strain upon his fairness is at times a heavy one, particularly when the specifications are so drawn that any interpretation of them is open to controversy. An examination of a number of legal decisions regarding classifications rather suggests the idea that at times the engineer has shifted his responsibility upon the courts. He has known that the contractor intended to sue, anyway, unless given more than was really earned, and accordingly has made his estimates as favorable to the railroad as his conscience permitted. In this way the court was enabled to have before it certain definite estimates and the reasons for them, and could pare them down as it saw fit.

This is theoretically all wrong, of course, for there should be some method of determining with

reasonable accuracy the lowest cost of the work plus a reasonable profit. Unfortunately no such method has been found as yet. Where certain kinds of material are encountered there will be a difference of opinion even between experienced contractors as to the best way of handling it, and these differences of opinion make money for the legal profession. There is a limit to the extent of the directions an engineer can give a contractor regarding the way the latter shall carry on his work, and if the latter insists that he can carry on his excavation in only one way he generally carries his point, while the engineer quietly emphasizes the accuracy of his own judgment by refusing to pay for the work except at a unit price based on a less expensive method. There has been a tendency of late to avoid all these controversies by calling for bids on the basis of a single unit price for every kind of excavation. This is not particularly onerous where the materials to be handled and their quantities can be estimated fairly well in advance of actual work, but where the contractor must expect sand, hardpan, schist and granite as hard as Pharaoh's heart, with all the rest of the fifty-seven varieties, he is facing a gambling proposition compared with which a brace faro game becomes as innocent as slapjack. In spite of this uncertainty, unclassified work is unquestionably receiving more and more favorable attention from both railroads and contractors. Railroad corporations are becoming so enormous that neither the chief engineer nor his principal aids are able to examine personally the materials, and they must approve perfunctorily the classifications made by subordinates. The contractor finds that even under approximately equivalent specifications, the classification of the same material varies on different roads and sometimes on the same road. If he bids on a favorable classification and an unfavorable one is made, he is likely to suffer financial pain; if he is too conservative and estimates that all the classifications will be against him, he will probably not land the contract. Hence he is likely to back his own judgment of what the whole work will cost and may prefer to take the contract on the unclassified plan.

It is gratifying to notice that Mr. Dennis's experience as both engineer and contractor leads him to believe that the unclassified price is not right in principle, and that paying by a proper classification is, in the long run, the most equitable method. This opinion has been held by The Engineering Record for some time, and it agrees with Mr. Dennis that the lack of any standard system of classification is probably the main reason for the growth of the contrary view that has lately been gaining favor. The standard specifications of the American Railway Engineering and Maintenance of Way Association provide for classification, but it is open to question if that classification is a marked improvement on those of some of the leading railroads. Any classification, to be satisfactory, must be definite, fair and demonstrable by test. To be fair it must group together the materials which are handled at about the same cost. It is manifestly as incorrect to place swamp muck and hardpan in the same class with sand and loose soil, as to group together shale and granite. Mr. Dennis proposes a classification based on the cost of the work, which seems a pretty good one except that it makes no definite provision for running sand, muck and similar troublesome grades of earth. It also has the fault of adhering to the old terminology of "earth," "loose rock" and "solid rock," which has proved a stumbling block to courts and the public more than once. There is no necessity of retaining these names, as it would be better in every way to refer to the grades as Class 1, 2 and 3, and thus avoid the verbal murder committed when "loose rock" is applied to material known as earth under all other conditions.

Although the classification suggested by Mr. Dennis is manifestly an improvement on many of those now in use, it may be questioned whether it will come into extensive use without a more complete study than it is likely to receive through the medium of a paper before the American Society of Civil Engineers. The inertia of custom which has retained in the standard specifications of some great railroad companies. classification clauses so indefinite and even impracticable as many to be found without much search, is not likely to be overcome except by concerted effort by influential men. While these clauses may be poor literally, their meaning has been fixed by usage, and those accustomed to them will be unwilling to adopt others unless there is some definite advantage in doing so. That there is such an advantage in a complete, practicable and equitable classification seems certain, provided it comes into general use. It will reduce the hazards of contracting wherever heavy excavation is done, and by so doing will reduce the cost of such work to the railroad companies. It is surely worth time and study to clarify the haziness which now makes trouble between engineer and contractor throughout the country, and for this reason it is suggested that the whole subject might very properly be referred to a special committee of the American Society of Civil Engineers. The excellent results that have followed the publication of the reports of the Society's committees on rail sections and cement prove that the painstaking thoroughness of the work of such bodies is recognized everywhere and generally standardizes practice. The Society includes among its members many men whose experience as engineers or contractors fits them admirably for service on such a committee, and their combined efforts will probably be able to formulate a standard specification for excavation and allied work which will be extensively adopted. This is an end to be earnestly desired. The construction of new railroads and the improvement of old lines calls for an enormous expenditure annually for excavation and embankment. A trifling percentage saving in that cost would mean a large total expressed in dollars, while a reduction of the constant friction between engineers and contractors due to the present imperfect specifications for this class of work would be beneficial in so many ways that it surely comes within the "advancement of engineering knowledge and practice," which is one of the Society's purposes as expressed in its Constitution.

Notes and Comments.

Factory Water Supplies for fire protection are notorious trouble-breeders, for the insurance people oppose metering them and water department officials have learned by bitter experience that mains intended solely for fire protection are subjected to strangely continuous drafts, only explicable on the ground that water is taken from them regularly for other purposes than that intended. The subject was under consideration a long time at Battle Creek, Mich., where a new schedule of rates was at last adopted, which reads substantially as follows: All users of water requiring large-size pipes for fire protection and other special purposes are required to pay a minimum annual rate for the use of water on the premises as follows: 8-in. pipe, $400; 6-in. pipe, $200; 4-in. pipe, $100; 3-in. pipe, $75; 2-in. pipe, $50; 1½-in. pipe, $35; 1-in. pipe, $20. Where there is more than one large pipe on the same premises there shall be an addition of one-half the rate for the first pipe for each additional pipe. These rates were adopted, according to the official statement, in order that the burden of carrying a supply of water at high pressure liable to surreptitious uses shall fall on the people who gain lower insurance rates and other advantages from it. The adoption of the schedule produced serious opposition, although there were few cases where the minimum rate was not below the regular charge for boiler purposes. Some companies tried rather unsuccessfully to develop private supplies. The schedule was devised by Mr. W. W. Brigden, city engineer of Battle Creek, who states that while it may be modified in some details as experience is gained in its operation, it is likely to stand as a whole. It is an unusual solution of the problem of fair charges for the expenses of a water department for fire protection purposes, and it is probable that water-works managers will follow its application with considerable interest. The Engineering Record is inclined to the belief that the use of detector meters on fire lines is a more equitable measure than the Battle Creek schedule, although the introduction of these special devices might be attended with greater opposition than the adoption of such rates.

The New York Building Laws are about to be revised, but there is a feeling among a good many people acquainted with codes in New York and other cities that it might be well to consider the advisability of a radical rearrangement of the regulations. It has been proposed to make the revision of the laws hardly more than an alteration in the requirements of some of the clauses of the present regulations, but there are people acquainted with building codes elsewhere, who think that the time is now ripe for a more thorough revision of the New York requirements. It is well known that in Chicago, for example, the building requirements are so prepared that it is a very easy matter for an owner of a building to find out just what laws apply to his particular structures, but in New York even architects engaged day in and day out in preparing plans are unable in many cases to know just what provisions of the code will be considered applicable to the plans they submit. This is due to an unfortunate lack of classification of buildings and is something that can be very largely avoided. At this time the New York code revision is in an early stage, and if the work is to involve a thorough recasting of the regulations, it is necessary at the present time to find out just what will be the best arrangement. On this account The Engineering Record suggests to its readers acquainted with codes elsewhere, that a communication from each of them who has had some difficulty with some special regulations in a code, or who has found that some regulation is particularly useful in facilitating good work and holding back bad designs, would be particularly helpful to the commission now engaged in revising the regulations in New York. On account of the importance of all building construction in New York City and the necessity of having the code cover all kinds of buildings, from small frame structures to the highest office buildings, and from small sheds for outdoor work to the largest industrial establishments, it is desirable that a very thorough investigation should be made before the suggestions for new regulations are debated finally. On this account The Engineering Record stands ready to publish suggestions from all its readers who are interested as designers and builders in such revision. It is only by a thorough consideration of what has been accomplished in other cities as well as by investigating serious difficulties that have arisen under existing codes that a model set of regulations can be drawn up. If such a set code can be prepared for New York, building operations throughout the country will be materially advanced.

THE RECONSTRUCTION OF THE PARKERSBURG BRIDGE ON THE BALTIMORE & OHIO R. R.

The Baltimore & Ohio Railroad crosses the Ohio River at Parkersburg, W. Va., on a long single track through bridge which included two 342-ft. channel spans originally built about twenty-five years ago. The Whipple trusses 33 ft. high and 19 ft. apart on centers were made with keystone column compression members and were divided into 22 panels about 15½ ft. long. The amount of traffic and the weight of the locomotives having increased greatly over the provisions of the original design, it was decided to replace the spans with stronger modern ones, and it was required that this should be done without materially interrupting the traffic and without obstructing the channel by falsework. The method finally adopted conformed substantially to that previously used in the reconstruction of the 348-ft. channel span of the Ohio River Bridge at Benwood, W. Va., described and illustrated in The Engineering Record of June 10, 1905.

The two new spans were erected by the cantilever method with trusses outside the old spans and clearing them and without imposing any additional load on the old spans, except that due to a very light erection traveler and to the delivery of members to it. Traffic was maintained uninterruptedly through the old spans while the new spans were erected outside of them and the traveler and service track were carried on top of the old spans. The anchorage reactions were balanced over the center pier, on both sides of which the new spans were simultaneously erected, and at the side piers they were provided for by temporary connections to the adjacent spans. The new floor beams were at first assembled below the final position to clear the existing old floor, which was blocked up on them after the new spans were swung. The old spans were then supported from the new ones during their removal and afterwards the new floorbeams were shifted to thir final position, the permanent track transferred to them and the old floor system removed.

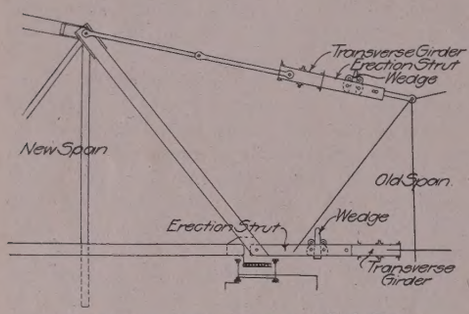
As the new spans are independent trusses in their permanent functions, it was necessary to make special provision for the temporary increased stresses, for the adjustments due to the cantilever method of erection and for the successive positions of the floorbeams. The principal features involved in these provisions are the details of the top and bottom chords, of the floorbeams and of the vertical posts. The new spans are 343 ft. 9 in. long, 56 ft. deep and 29 ft. 6 in. wide on centers with pin connected trusses and curved top chords. The latter were made in single panel lengths and the center panel section was made about 6½ ft. short, so that the connection pins for its diagonals were contained in the adjacent sections and permitted all of the other members of the panel to be erected before the top chord section was assembled and which was then spliced to them at both ends with field riveted web and cover plates. The bottom chords are stiff members with built channels latticed on the top and bottom flanges. The end sections, 66 ft. 8 in. long, extend beyond the second panel points to provide a field riveted connection bepond the panel points L2 and thus permit the vertical and diagonal members to be assembled there before the next chord section is added.

This relative position of the chord splice is maintained in the succeeding panels, so that in the center panel there are two field riveted prices for the short middle section of the bottom chord, as in the top chord. The middle section of the bottom chord, L6 L6, is only 12 ft. 10 in. long on pin centers, while the panel has a length of 31 ft. 1½ in. uniform with the other panels of the bridge. This corresponds with the location of additional pin holes L6, 9 ft. 1¾ in. beyond the regular bottom chord pins L5 at the regular panel points. The main sections of the lower chord are therefore extended about 10½ ft. beyond the panel points L5 to receive the extra pin holes which pass through the regular webs and the center diaphragm at their extremities, all three being heavily reinforced so as to give a total bearing of 12⅜ in. for the 9-in. pins. In one of the lower chord sections, this pin engages a hole 9 1-16 in. in diameter, but in the other section the hole is slotted to a length of about 15 in., allowing 6 in. longitudinal play for the final erection adjustment. The center section of lower chord L6 L6 is made with four webs dovetailing with the three webs in the adjacent sections and is bored with holes closely fitting the pins L6L6.

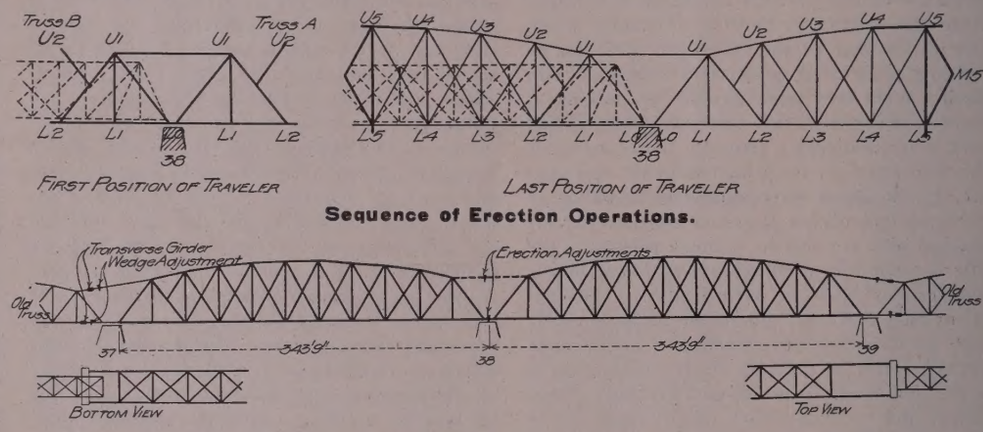
The plate girder floorbeams, 48 in. deep and 28 ft. 1 in. long over all, are of the ordinary type with pairs of 6x6x⅝-in. flange angles reinforced by several 14x⅝-in. plates. The webs are made in three sections, the short pieces at the ends projecting beyond the top flanges to provide for a long vertical field riveted connection to the vertical posts, and are cut to clear the bottom chords. In their temporary position they were bolted to the vertical posts with the bottom flange up, and the stringers were temporarily connected to them 19 ft. apart on centers instead of 7 ft. apart as required for their final position. Two sets of open rivet holes were therefore made in the floorbeam webs to provide for both connections, and after the second connections were made the open holes which had served for the temporary connection were filled by field driven blank rivets.

In order to provide for the temporary lower position of the floorbeams, the vertical members of the trusses were made to project 10 ft. 10½ in. below the center line of the bottom chord, and were provided with double sets of open holes for the floorbeam connections, one set above the chord pin for the permanent connection and a similar set at the lower end of the post for the temporary connection. After the permanent connection of the floorbeams had been made, the projecting lower ends of the vertical posts were cut off by hand in the field flush with the lower flange of the bottom chord.

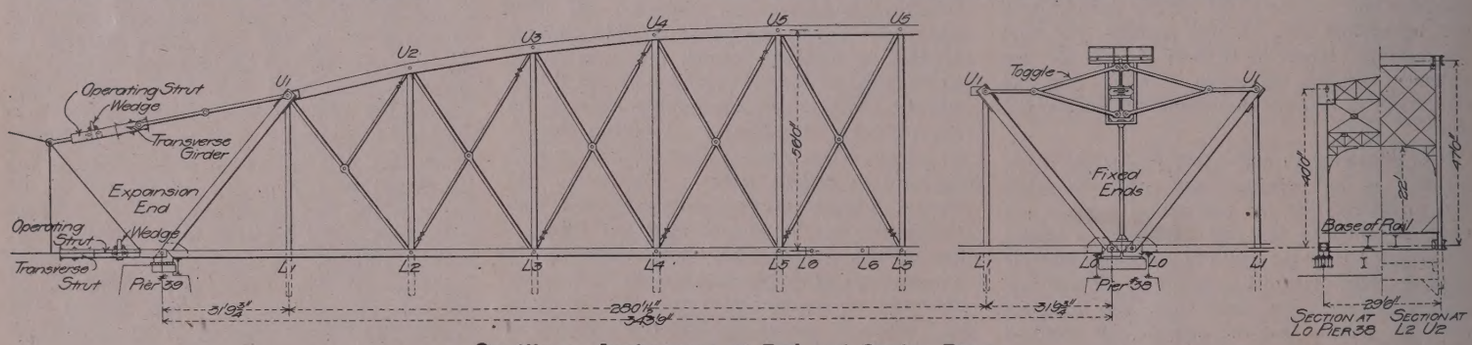
As the new trusses are 10 ft. 6 in. further apart than the old ones, their bearings are so near the ends of the piers that the concentration of the heavy loads there would have created too great unbalanced pressures on the masonry and a system of distribution girders was provided to secure the uniform and symmetrical loading of the pier masonry. At pier No. 38, which supports the adjacent ends of both new spans, a rectangular framework was formed with two plate girders 5½ ft. deep transverse to the axis of the bridge, extending the full length of the pier, and connected by a pair of center diaphragms and by sets of grillage beams at both ends to receive the weight of the superstructure and distribute it



Adjustable Anchorage to Old Span.

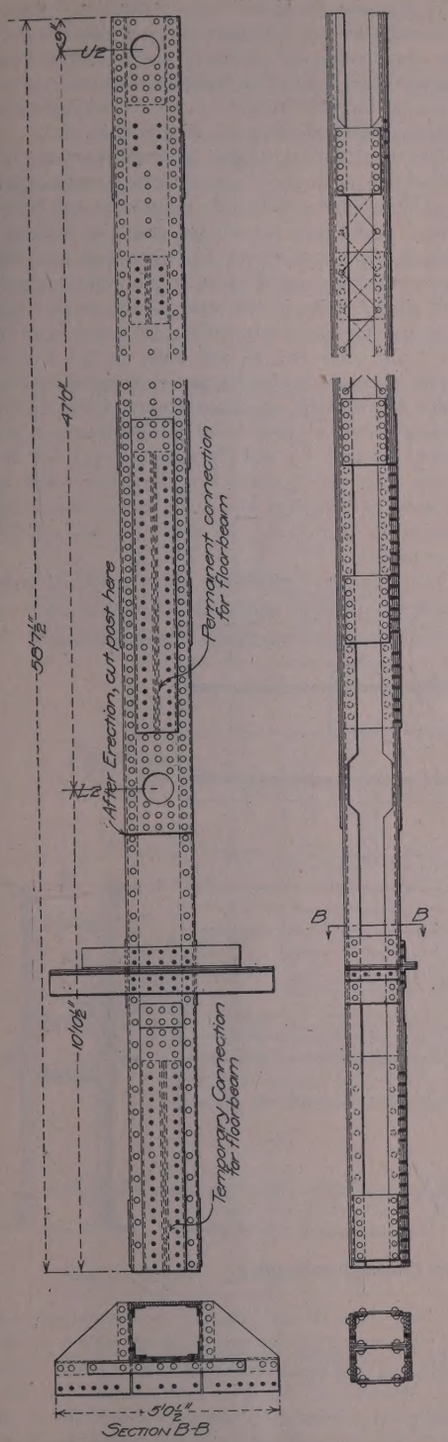


Sequence of Erection Operations.

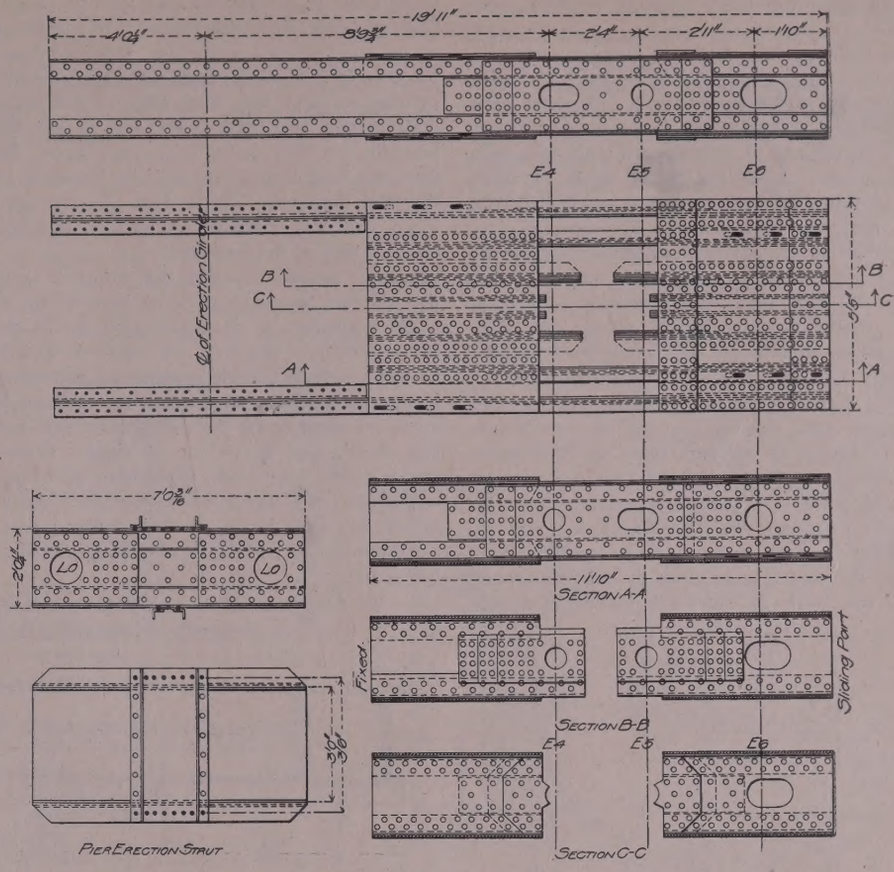


Cantilever Anchorages at End and Center Piers.

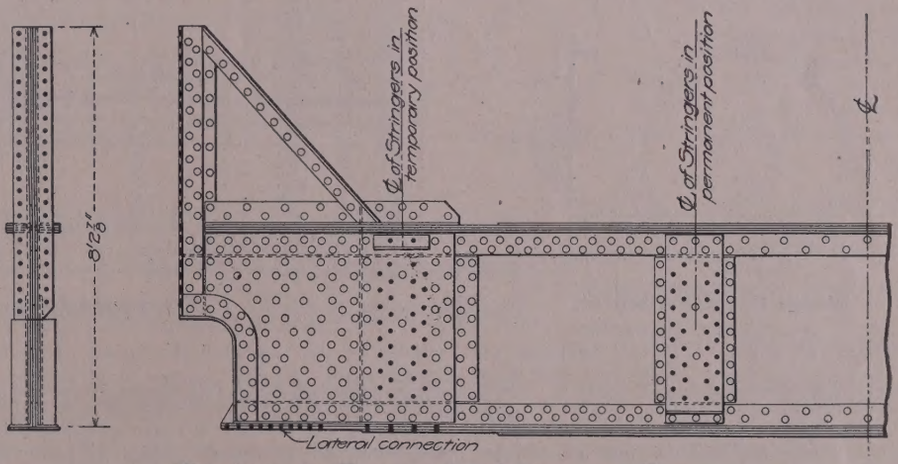
New Spans and Temporary Erection Connections.



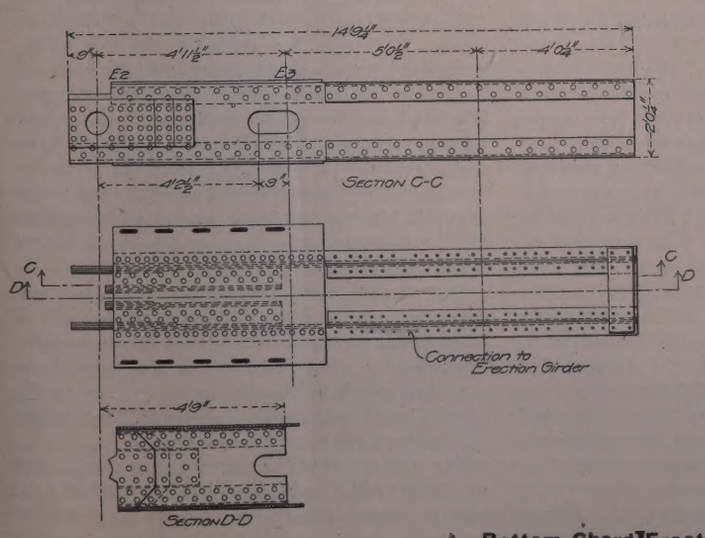
Post With Connection for Temporary Floorbeam.

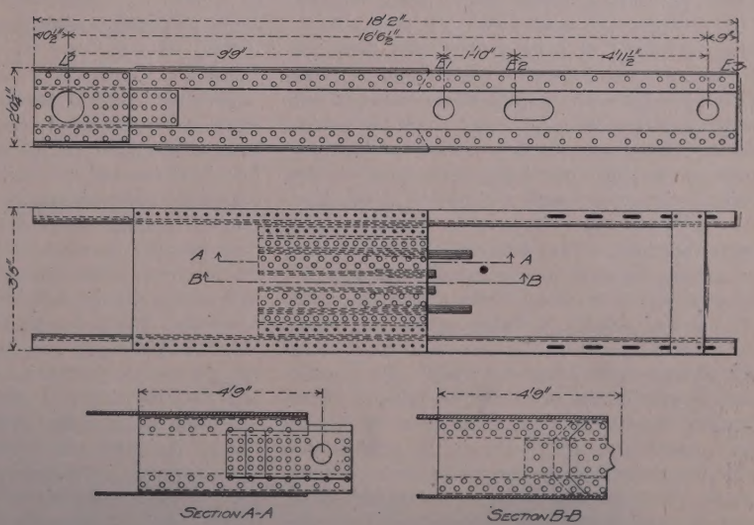


Erection Adjustment Struts.



Floorbeam for Temporary and Permanent Floors.



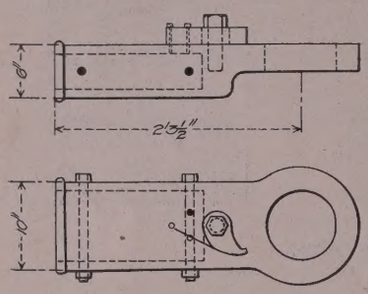


Bottom Chord Erection Adjustment Struts.

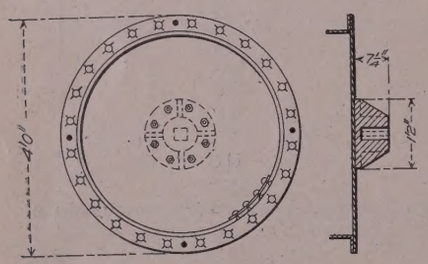
through the continuous bearings of both main girders.

The main girders were of massive construction with a single web plate 5/8 in. thick and with duplicate top and bottom flanges each made with two 12x5/8-in. vertical plates, two 6x6x5/8-in. angles and three 14½x5/8-in. cover plates, all single, full-length pieces. Each grillage is a set of three plate girders with a 36x½-in. web and two 6x3½x5/8-in. angles in each flange. The three girders are connected by a single 59½x1-in. top flange cover plate riveted to all of them and are field-riveted through their end vertical connection angles to the webs of both main girders. The intermediate diaphragms are single plate girders corresponding with the units in the grillages.

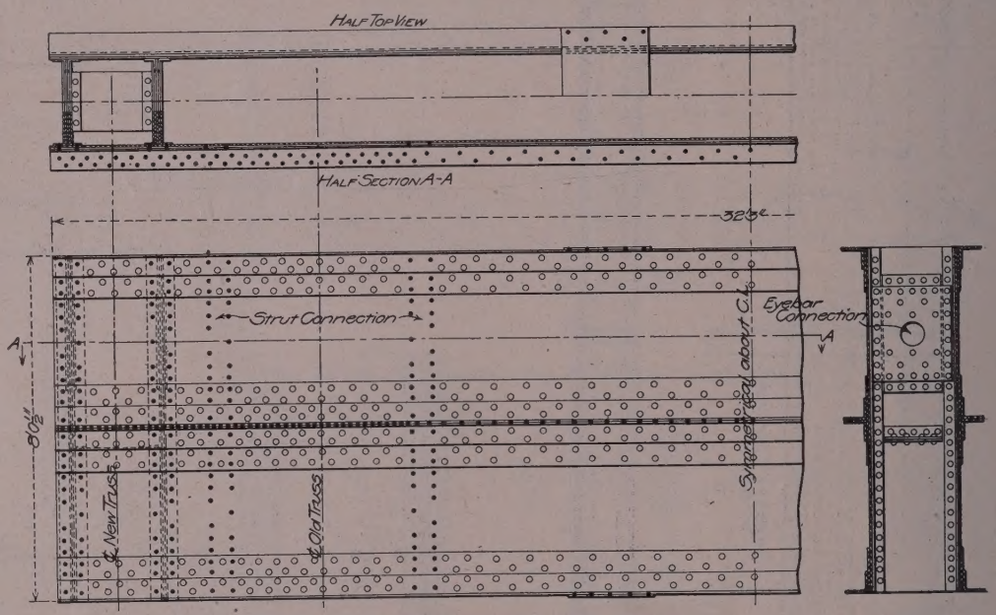
Piers 37 and 39 at the opposite ends of the new spans each support one end of a new span and one end of an adjacent span, the loads from the former are distributed over the masonry by pairs of transverse main girders connected by grillages on the same principle as for pier 39, but differing from them in their eccentric location on the pier tops to clear the adjacent spans and in the provisions for single instead of double



Ratchet Lever Socket.



Wedge Operating Wheel.



Transverse Girder for Top Chord Anchorage.

bearings on each grillage. The arrangements for both piers are duplicates except that they form rights and lefts.

The main girders, 44 in. deep and 35 ft. 4½ in. long, are similar to those for pier 38, and are made with 5/8-in. web plates, 6x6x5/8-in. flange angles and three full-length 13x5/8-in. flange cover plates, the vertical flange plates being omitted. The grillages are made with six 20-in., 80-lb. I-beams instead of plate girders, and their top flanges are shop-riveted to 67½x1x6 3½-in. cover plate provided with bearing ribs parallel to the bridge axis for the roller nests under the bridge shoes. Guard and cover angles are also provided on the sides of the grillages to enclose the ends of the roller nests and protect them, thus making the grillages serve as pedestals for the roller bearings. The intermediate diaphragms connecting the main girders are plate girders, 27 in. deep and 7 ft. long, made with 3/8-in. webs and pairs of 3½x3½-in. flange angles.

As the old 342-ft. spans were required to carry the traveler and its loads besides the regular train service during erection, very careful investigations were made of the maximum stresses in four cases: first, for the train in combination with the dead load of the bridge and traveler; second, for dead load in combination with dead load of traveler and lifted loads; third, for train in combination with dead load of bridge and with up-lifts due to unbalanced loads; fourth, for dead load of bridge in combination with up-lifts due to unbalanced load, neglecting the dead load of the traveler. Computations were made with the assumption that the dead load of the trusses, floor system and track was 3,400 lb. per linear foot, the live load of the train 5,000 lb. per linear foot, the dead load of the traveler 70,000 lb., and that the maximum live load on the traveler, or lifted load, was 20,000 lb. for each of two booms on each side of the traveler.

It was further assumed that when in service the traveler would always be blocked up over panel points so as to concentrate the loads in these positions, and that the traveler would be moved only when the bridge was free from train loads and would then develop an extreme fibre stress of about 1,500 lb. per square inch in the top chord, due to its own weight. Complete strain sheets were made with these data, and in accordance with them the intermediate posts of old trusses were braced at their center points by a continuous line of horizontal longitudinal timber struts.

As the planes of the new truss were 5 ft. 3 in. outside of the planes of the trusses of the adjacent spans, the new trusses could not be directly connected to the adjacent ones to develop anchorage reactions in the latter, therefore special horizontal transverse girders were provided in the panels of the top and bottom chords of the adjacent spans and projected beyond their trusses to receive the connections to the new trusses, acting as double cantilevers to transfer the longitudinal stresses from the outer to the inner planes.

The hip joints of the trusses of the adjacent spans were connected over piers 37 and 39 by inclined eye-bars engaging the top chord pins U1 U1 at one end and at the other end engaging horizontal pins through the ends of longitudinal riveted members field-riveted at their opposite ends between the webs of the transverse girders. These struts, about 20 ft. long, were each made with two I-shaped members 5 ft. 5¼ in. apart over all, connected with top and bottom flange plates. At the pin end, two intermediate vertical webs were riveted between the flange plates and were bored with a slotted hole at the outer extremity and a round hole at the opposite end nearest the transverse girder. A second pair of webs were set in the spaces between these webs and the main webs of the member and were secured by bolts through their flanges which engage slotted holes in the top and bottom cover plates. The opposite or girder end of these webs was connected by top and bottom cover plates engaging the flanges of the main webs and having slotted holes for bolts engaging the latter, thus allowing the pair of webs to move longitudinally 2½ in. back and forth inside the main strut.

The cover plates of the intermediate webs received a pair of short center webs corresponding with those in the end of the main strut and bored with a round hole for pin E4, and with a slotted hole for the center pin, E5. The end pin, E6, passes through round holes in the moveable web and slotted holes in the webs of the main strut. The center pin, E5, passes through round holes in the main strut and slotted holes in the sliding strut. The third pin, E4, passes through slotted holes in the fixed strut and round holes in the sliding strut, so that when wedge bearings are placed on pins E4 and E5 and a wedge set between them, the operation of the latter tends to shorten or lengthen the strut connection, thus raising or depressing the cantilever end of the new truss.

The transverse girder to which the fixed ends of the adjustment struts are riveted is 32 ft. 3 in. long over all and has two horizontal webs 8 ft. wide and 24¼ in. apart. Each web is made with two 48x3/8-in. plates spliced together with two longitudinal 12x12-in. cover plates and two longitudinal 6x6x5/8-in. angles shop-riveted to it on the outside and making flanges which are field-riveted together to enable the girder to be assembled in sections. The girder flanges each consist of a 12x½-in. web plate and a 6x6x5/8-in. angle. The webs are connected by two transverse diaphragms 25¼ in. apart on centers at each end, which are field-riveted to the webs, thus enabling all members of the girder to be assembled separately in the field. These diaphragms have their vertical webs bored to receive the pins connecting them to I-bars extending to the top chord pins, U1, of the cantilever trusses and completing the erection connections between the adjacent spans.

The adjacent ends of the two new spans are connected across pier 38 by special temporary longitudinal girders in the planes of the trusses. These girders, marked Lo Lo, are about 7 ft. long over all and have double webs 3 ft. apart on centers bored to engage 10-in. pins Lo Lo, through the fixed pedestals of the new trusses.

The bottom chord erection adjustments are provided at the end piers 37 and 39 by longitudinal struts in the planes of the new trusses which engage at one end the lower chord pins Lo,

in the expansion shoes of the cantilever trusses and are bolted at the opposite end between the webs of transverse erection girders similar to those already described for the top chord adjustment.

The bottom chord struts are telescopic and are designed on the same principle as the top chord struts with a main member 18 ft. 2 in. long having a pair of outside webs 34½ in. apart connected by top and bottom cover plates field-riveted to their flanges and carrying short intermediate longitudinal webs bored with round holes for pin E1. The other part of the strut is 14 ft. 9¼ in. long over all and is riveted at one end between the webs of the transverse girder. It has two webs 15⅜ in. apart in the clear which project at the free end between the webs of the wide strut and have shop-riveted to their flanges top and bottom cover plates projecting across the flanges of the wide strut which they engage. They are provided with slotted holes 5½ in. long through which 1-in. bolts engage corresponding slotted holes in the flanges of the wide strut. The struts are thus guided and permitted to move back and forth longitudinally.

The webs of the narrow strut are bored with one slotted hole and one round hole and those of the wide strut are bored transversely with one slotted hole and two round holes, the arrangement being reversed so that pins E1 and E3 are fixed and E2 is moveable in the wide strut. Pin E1 does not engage the narrow strut. Pin E2 is fixed in the narrow strut and movable in the wide strut, while pin E3 is moveable in the narrow strut and fixed in the wide strut. Therefore when wedge bearings are set on pins E1 and E2, and pin E3 is driven to engage both struts, wedges operating between pins E1 and E2 serve to extend or retract the bottom chord and thus provide for the erection adjustment at the center panel of the new truss.

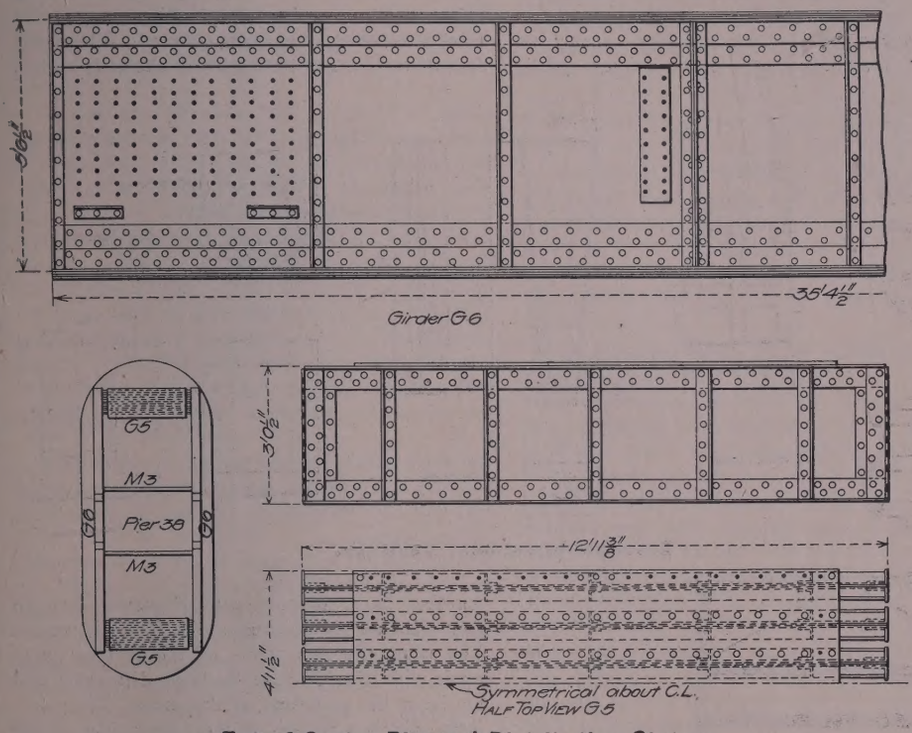
The transverse erection girders are each made in four duplicate field-connected pieces with 48-in. webs 32 ft. 3 in. long over all, like those for the top chords, but differ from them in their connections. The connection to the new span is made directly with the operating strut bolted between its webs, and that to the adjacent truss is similarly made by bolting the lower chord between the webs. The stresses transmitted through these connections are in compression, therefore no I-bars are required and the diaphragms and pin bearing provided between the webs at the ends of the top chord transverse girders are dispensed with and the different sections of the girders are entirely separate except as connected to the other members already mentioned.

Of the eight transverse girders required for the simultaneous erection of the two spans, four were built new for this bridge, and the other four were girders which had been used for the same purpose in the erection of the Benwood Bridge. The details and dimensions of the old girders are substantially the same as of the new ones, except that the open holes through the webs for the bolted connections to the operating struts and to the old bottom chords were not in the proper positions and it was necessary to drill new ones. Old holes through the angles and reinforcement plates were filled with blank rivets, but those through the web only were left open.

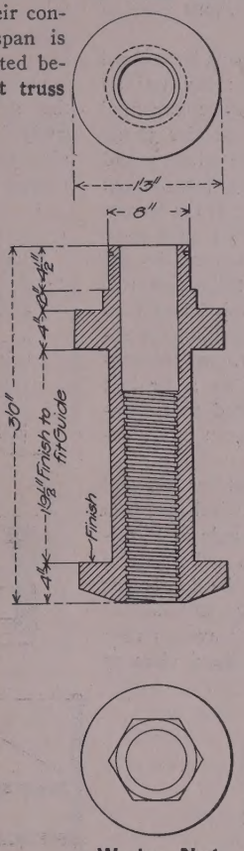
The anchorage reactions of the adjacent semi-span cantilevers were balanced by connecting the tops of the inclined end posts with adjustable tension members extending across the top of pier 38 in the planes of the new trusses. These members consisted of horizontal I-bar chains having a center link composed of four inclined I-bars forming the sides of an oblique parallelogram and fitted in the center vertical diagonal with a compression screw forming with the I-bars a powerful toggle joint with a capacity superior to the estimated moment, 68,000,000 ft. lb., of the semi-span. The vertical operating screw 8 in. in diameter and 16½ ft. long was provided with 5½ ft. of right and left-handed square threads at both upper and lower ends. In the center it was keyed to a 10-in. horiontal spur gear 4½ ft. in diameter with 48 teeth engaging a pinion on a vertical shaft, and at the upper end it was keyed to a horizontal flanged wheel 4 ft. in diameter which served as a drum engaging two or three turns of a Manilla rope leading to the hoisting engine by which the toggle was satisfactorily operated.

The screw ends of the vertical member engaged square cast-steel nuts 11½ in. thick with top and bottom horizontal saddle beams bored at the projecting ends for the pins engaging the inclined I-bars of the toggle joint. A vertical screw was fixed in bearings each side of its spur wheel and both ends were free. The torsion on the saddle beams was balanced by the diametrically opposite I-bars, and they moved up and down without vertical guides. A platform and the toggle screw was supported by a light riveted framework carried by a vertical strut seated on the center line of pier 38, as indicated in the assembled elevation.

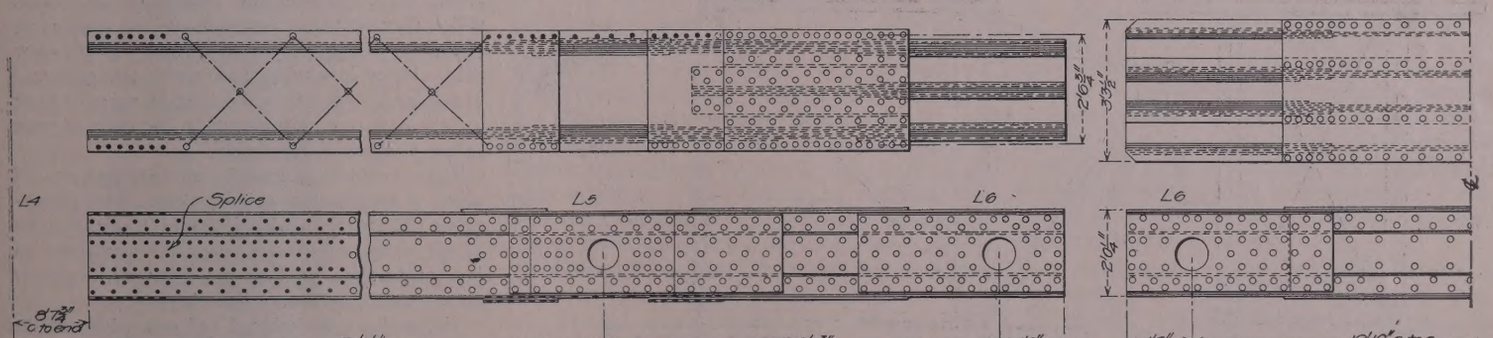
The wedge adjustments for the operating struts in the top and bottom chords were of ordinary design, the wedges about 6 ft. and about 4 ft. long, being made of cast iron with a taper of about 1 : 12. The sides were polished and had center longitudinal guide ribs, and a vertical hole through the axis was tapped at both ends to engage the operating screw 5½ in. in diameter with check nuts engaging the upper and lower ends of the wedge. The screw projected about 8 ft. beyond the top of the wedge, which in every case was placed with the point upwards and engaged



Top of Center Pier and Distributing Girders.



Wedge Nut.



Center Panel Lower Chord.

a circular cast-steel nut 3 ft. long with a fixed ratchet wheel and a moveable pawl on the upper end. The nuts were journaled in vertical cast-steel guide-posts bolted to riveted pedestals seated on the operating struts. The cast-iron pawls were socketed to receive capstan bars by which the wedges were operated by two men on each bar. The wedges took bearing against polished cast-iron side pieces engaging the 6½-in. pins through the telescopic operating struts and held against turning by additional 4½-in. pins through their upper ends.

The adjacent ends of the new spans have fixed bearings on pier 38 and expansion bearings on the end piers 37 and 39. Erection was commenced on all three piers simultaneously. At pier 38 the shoes were seated on the grillage girders and were connected by the temporary longitudinal erection girders, and the assembling of the trusses was commenced by a traveler moving on a 19-ft. gauge track laid on the center lines of the top chords of the old spans. With it the first two panels of both spans were assembled and connected by the I-bars and toggle engaging the opposite end top chord pins U1 U1, and conventionally indicated in the diagram by a straight line. This apparatus really consisted of a combination of several members, as shown in the detail elevation of pier 38.

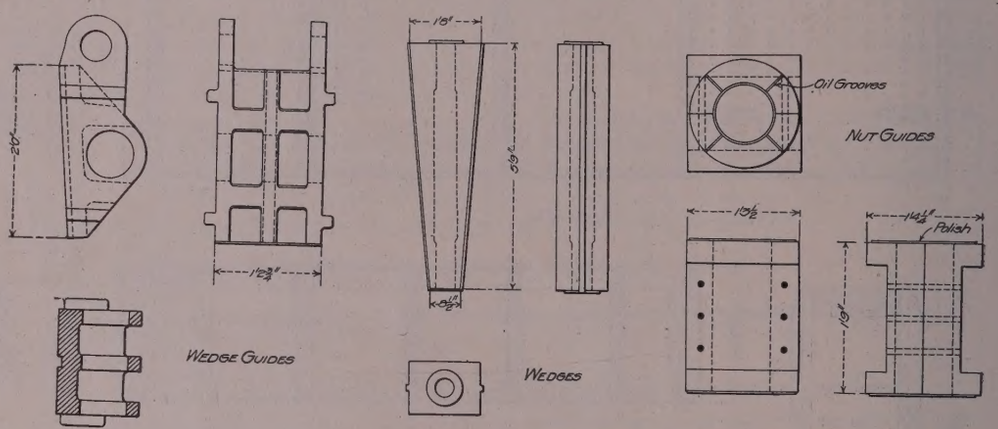
The inclined end posts were first erected and shored to the old spans, the end vertical members were connected to them and the toggle and erection adjustment were put in place. The bottom chord sections were assembled and the floorbeams at L1 erected in a temporary position and blocked up against their old trusses. The travelers then advanced away from each other toward piers 37 and 39, and in the second position erected vertical posts L2, U2 and one panel top chord and two semi-diagonal members. Eleven more movements of the traveler sufficed to complete the erection of the semi-spans to points U5, L5, as indicated in the diagram, the maximum up-lifts resisted by the old trusses being respectively 75,000, 63,000, 44,900, 47,000, 33,400, and 36,200 lb. at panel points L1, L2, L3, L4 and L5.

Simultaneously with these operations, two more duplicate travelers had erected the opposite halves of the spans in a similar manner from piers 37 and 39. Finally the travelers all advanced to the last panel; meeting at the centers of the spans, and completed the erection by assembling the center top chord sections. The positions of the semi-trusses were intentionally kept somewhat above their required levels and were easily lowered by the adjustment devices until the required clearances were secured for the top sections, and were assembled and put in place without difficulty. The maximum loads on the traveler booms were 20,000 lb., and the booms had a radius of 27 ft., the bottom chord sections being handled with double booms and all other members with single booms.

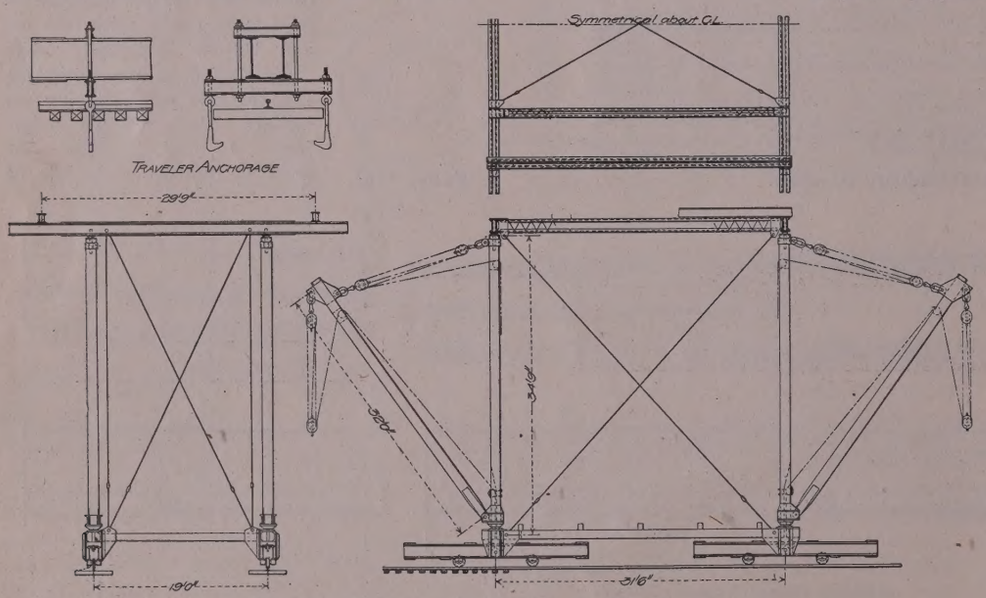
As much transverse bracing as could be made to clear the old span was put in as fast as the erection progressed and all field rivet holes were filled with service bolts. The floorbeams were erected in the first position, bolted to the lower ends of the vertical members. Stringers were temporarily assembled to them in the planes of the old trusses and blocking was immediately wedged up on the top flanges of the stringers to give bearing for the panel points of the old trusses. Traffic was maintained uninterruptedly on the original track and old floor system, until the completion of the erection of the new trusses and the subsequent removal by the same travelers of the old trusses.

The stringers in their temporary position were braced together with zigzag wooden struts bolted to their bottom flanges. The erection of the permanent floor was commenced at pier 39 and the new floorbeam was put in its final position at L1, after which the first floorbeam in the temporary position below it was removed and put in its permanent position at L2 and the stringers were replaced in their final position at the upper level in panel L0, L1. The succeeding panels in both spans were changed in the same manner, traffic of course being interrupted while the operations were in progress. The work was arranged, however, to conform nearly to the regular intervals between scheduled trains, so that four hours was the longest period in which the bridge was out of service. No interruption had been caused to the train service during the erection of the trusses, care having been taken to make the final adjustments in the center panel at a regular interval between trains.

The four erection travelers were of very simple construction, consisting virtually of rectangular towers 19 ft. wide, 31½ ft. long and 35½ ft. high on centers, mounted on four two wheel trucks. The wooden vertical posts of the tower served as masts for four wooden derrick booms 30 ft. long. The longitudinal sills were each made with a pair of 8x12-in. timbers having vertical steel gusset plates bolted to both ends and projecting below the lower edge of the sill to engage the trucks to which they were pivoted. The truck frames were made with pairs of channels riveted together back to back with clearance between their webs for the hoisting and topping lift tackles. The transverse top struts of the traveler were made with pairs of channels latticed together and receiving the gudgeons of the mast. They projected about 9 ft. beyond the center lines of the masts and carried pairs of longitudinal I-beams about 5½ ft. beyond the centers of the masts, which thus served as jigger beams for supporting tackles in the planes of the trusses of the new span. When in service the traveler was anchored to the top chords of the old span by pairs of hook bolts with screw adjustments in the ends of yoke beams clamped to the trucks.



Erection Adjustment Castings.



Erection Traveler Supported on Old Spans.

The erection was made by an average force of about 32 men in 173 working days. The complication due to the maintenance of traffic, the removal of the old structure and the alterations in the substructure making the work much slower than it would otherwise have been.

The bridge was designed and erected under the direction of the engineering department of the Baltimore & Ohio Railroad Co., Mr. J. E. Greiner, engineer of bridges and later assistant chief engineer. The steel work was fabricated and erected by the King Bridge Company, Mr. H. A. Fuller, chief engineer, and Mr. D. A. Sheedy, superintendent of erection.

LEAKING WATER MAINS in Vicksburg, Miss., must be repaired within two days of the beginning of the leakage or the owner of the water-works or its manager is subject to a heavy penalty. At present the water-works there are owned by a private company, and its manager was recently convicted of violating this ordinance by allowing prolonged leakage from a main at a point when the street in which it is laid is crossed by a railroad. The case was appealed to the Mississippi Supreme Court, but decided against the manager, the court ruling that the ordinance was a justifiable police regulation for the purpose of keeping the streets in proper condition.

The Classification of Excavation and Embankment.

One of the most interesting and important papers presented before the American Society of Civil Engineers in some time was that on "Uniformity of Requirement and Clearness of Specification in Agreements for the Graduation of Railroads," which came up for discussion on Wednesday of this week. The author is Mr. W. F. Dennis, and the full text of the paper appeared in the Society's "Proceedings," vol. xxxiii, p. 39. The author's long experience in railway work and the frequent and bitter controversies regarding payment for excavation and embankment combine to make the paper one deserving careful study and thorough discussion. The main points brought out in it are given in the following abstract:

Nearly all railroads find it useful to retain classifications in their forms of agreement. Such classifications give a solid rock material at one end, and an earthy material at the other, with, generally, an intermediate material called loose rock, and frequently an additional hardpan classification. Where the experience of the subordinates, who do the actual classifying, of the management, and of the contractors, is fairly well established for a particular section, this classification works out well, with very little friction, and, in the writer's opinion, with cheaper final results to the railroad and more satisfactory results to the contractor.

Twenty-five years ago an unclassified price was exceptional; to-day much the larger volume of excavation is paid for unclassified. If any tendency can be discerned, it is strongly in the direction of letting all excavation unclassified; or of limiting it to one classification for rock, and another for all other materials.

On the part of the railroads there is the argument that classification is prolific of lawsuits, and there is an unfounded belief that an unclassified price prevents them. Besides this, the growth of business brought about by consolidations and extensions leaves scant time for investigation by the Chief Engineer. There is also a process of extension of operations and centralization in management in the contractor's business. On different roads he observes classifications which are not exact, largely modified by custom, and finds that custom varying with individual engineers in charge, and, from time to time, even upon the same railroad. However exact the contractor's estimate may be, on what he considers a proper classification, he is practically at sea as to what is to be paid. Should he bid upon an anticipated favorable classification, it might be changed during the progress of the work; if he assumes the unfavorable, possibly he may lose the work. In addition, he thinks that he has clearly detected instances where classification was influenced downward by financial considerations, pressure from the management, preliminary estimates being exceeded, and so on.

As a result of these uncertainties, the writer believes that most of the responsible contractors of to-day, in weighing the two hazards—their own both as to proportion and cost of materials, or the other as to what kind of classification they will get from the engineer—generally prefer to take their own risk upon an unclassified price. In making an unclassified price, the contractor not uncommonly finds difficulty in getting bidding information which is sufficiently clear as to quantities and disposition of material. Some engineers present a profile, but refuse to give quantities in detail, being afraid that claims may be made if there be any change. Contractors, to keep their business going, are compelled to bid in the form in which the engineers require. Under such circumstances they make the best approximation possible.. It is economically wrong to let the work too high or too low, and the engineer is inexcusable who does not secure and present clearly every piece of information that will eliminate the risk of the work as much as possible.

In spite of the apparent satisfaction of both sides with the unclassified price, the writer believes that it is not right in principle, and that paying by a proper classification is, in the long run, the most equitable and reasonable method.

As before stated, the basis and aim of classification are to associate in one group classes of material for which the cost of handling is approximately the same. The class, location and magnitude of the work, and the kind of equipment which is best adapted to it, have a very important bearing upon the cost, even of the same material. The association of one material with another on the basis of similar cost, therefore, might be proper in one case and not in another. For work suitable only to scrapers, it is inconsistent to embrace, in the same classification, earth, sand, gumbo and cemented gravel as apparently equivalent. If it is assumed that the work is to be done by steam shovel, many of the items of loose-rock cost for hand work will approximate the cost of an equal quantity of earth.

The company agrees to pay definite prices for definite services in a definite time. The contractor thereupon proceeds to perform the service, providing such appliances as his judgment, particular plant, or financial ability, will justify. If he knows exactly how he is to be paid, he can then make his calculations as to heavy-plant expense and lower working cost, or the reverse, and longer or shorter time. If a classification is desirable it should not be changed by the plant investment. The classification of a given material should be rigid, for removal by any appliance, and irrespective of quantities or location. The classification should be made, not by means and descriptions of material, but by some definite physical characteristic susceptible of uniform test.

A simple measurable test, easily applicable, and defining what should be properly in the "earth" classification, is whether or not the material can be ployed in its natural state by a definite plow pulled by a definite number and weight of stock. Whether this material is moved by scraper, grader, cart, car, wheel-barrow, or steam shovel, what is meant is clearly described, namely a material which a designated plow will produce in shoveling condition. This description excludes from the earth classification some material included in some earth specifications, and includes some material which, in others, is classed as loose rock or as hardpan.

The reason for placing the earthy material, sometimes included in earth and hardpan classifications, in the loose-rock classification, is the obvious one of similarity of cost. If the material is too wet to be plowed, as in case of swamp muck, quicksands and some gumbos; or is too hard to be plowed, like hardpan, cemented gravel, etc., holding to the proper theory of grouping by rough similarity in cost, no designation by name can properly make it "earth," in a cost sense, for all appliances, although it might be for some. Additional costly work may be required to get the material loaded or transported. In some cases the cost of unplowable earthy material may approximate and exceed that of solid rock; but, speaking generally, the cost is somewhat similar to the cost of loose rock, and such material is most fairly included in that classification.

Mr. Dennis quotes the definitions of solid and of loose rock contained in the specifications of some of the leading railroads, and concludes that they reduce to about this: Rocky material which can be removed without blasting is loose rock; and that which cannot is solid rock. That word, "can" is the whole of the question, and causes most of the disputes about classification. The word "can" is complicated by the fact that it is nearly always cheaper to blast so-called loose rock than pick or bar it apart, and, further, undeniably solid rock can be disintegrated by slow degrees without blasting. The word "can," then, for reasonable interpretation, depends upon some rate of removal. A solid mass of rock might be seamy to the extent of permitting wedging or barring out 1 or 2 cu. yd. per day, but that possibility does not make it loose rock. On the other hand, a certain material might be dug slowly by a steam shovel without blasting. If it could be loaded faster, as a result of blasting, it would be taken out customarily by blasting, but, under the specification, that fact would not necessarily make the material solid rock. On the other hand, the same material, under nearly all specifications, might be solid rock by reason of the impracticability of removing it with pick or bar with reasonable rapidity.

Taking a general view, the difference between materials in a construction sense is obtained from consideration of the operations necessary in loading such material on their transporting appliances. Earth is a material which can be reduced to loading condition by plowing, or equivalent inexpensive picking or blasting. Loose rock is a material which generally can be put into handling shape by picking, barring and light sledging, or, in lieu thereof, by moderate blasting, but it is not quite as easy to load as earth. Solid rock is a more refractory material, requiring drilling, strong explosives, and general sledging, and, with this additional expense, is not capable of reduction to a loading condition as favorable as the other materials. The requirement of ringing under the hammer is inapplicable; the expression, "continuous blasting," is inexact, and can be worked as a swindle by either side.

Can a physical uniform test be applied? It is known that certain soft or fractured rocks can be picked or barred apart with reasonable rapidity, and customary specifications state the fact, but do not state the rate. By definition of that rate the classifications of rock can be clearly defined. Mr. Dennis thinks that, keeping close to current practice in classification, the rate of disintegration for loose rock should be within the performance of two men thus employed. A material requiring more than two men working with pick and bar to keep one shoveler busy is certainly a material that "may better be removed by blasting" and which "can only be removed by blasting" in a reasonable sense.

A consideration of importance is the size of the rocky mass that must be exceeded in order to constitute a solid-rock classification. In handwork an isolated mass of 3 cu. ft. can be handled without much difficulty; but any larger mass will require disintegration before loading. Bearing in mind the theory of trying to fix classification by similarity of cost, the writer thinks that 1 cu. yd.—the limit most frequently specified—is too high; 3 cu. ft., although right in one view, is probably too low; and that the compromise limit of ½ cu. yd. would be about right. This limit was formerly common, and is still retained in some specifications.

In an endeavor to set forth the foregoing more clearly, Mr. Dennis proposes the following as an outline classification:

Earth.—Material which in its customary natural condition can be plowed—or is equivalent to a material which can be plowed—with a plow cutting a furrow 10 in. wide and 10 in. deep, drawn by a team of 4 horses, or mules, each having an average weight of 1,100 lb., and moving at a reasonable plowing speed, shall be classified as earth.

Loose Rock.—The following shall be classified as loose rock: Earthy or mixed materials, not susceptible of plowing under the foregoing test; soft, fractured, disintegrated or other rocky material, soft or loose enough in its natural condition to be barred or picked apart by two men thus employed serving one man shoveling or loading by hand; solid rock in separate masses exceeding 1 cu. ft. each, and not exceeding ½ cu. yd. The continuous or occasional use of explosives, at the contractor's option, shall not affect the classification, but it shall be governed solely by the test above set forth.

Solid Rock.—The following shall be classified as solid rock: Rocky material in masses exceeding ½ cu. yd., which cannot be broken apart, or displaced from its natural position, except by the use of explosives; and other rocky material which cannot be picked or barred apart by two men thus employed serving one man shoveling or loading by hand.

The principal point aimed at is clearness of test and classification. Experiment will determine whether or not the material can be plowed, and actual picking or barring of the material will determine whether or not two men can keep one shoveler going. Rigidity of classification simply makes clear how a given material is to be paid for. With this information, the price for the material can be made intelligently by the contractor in view of his experience with similar material and his knowledge of local conditions.

For heavy steam-shovel work, Mr. Dennis' opinion is that there is no especial benefit in a distinction by classification between loose rock and earth, and, for that class of work, a classification for solid rock and another for all other material would be sufficient; but nearly all steam-shovel work involves more or less miscellaneous accessory work for team and hand appliances, and the loose-rock classification is needful for them; furthermore, classification on all work would become better established by its uniform practice.

Almost universally, specifications provide payment for excavating foundation pits for structures. Some specifications provide for payment for the material in coffer-dams as well as for excavation Here the dispute comes as to the necessary quantity of excavation and the form, material and size of the coffer-dam, all of which are under unspecified control. The most frequent custom, and apparently the best, is to leave the material and design of the coffer-dam or support to the contractors, make him responsible and pay by some definite stipulation.

The following seems to Mr. Dennis to be reasonable practice and definition: Excavation for foundations of pipes, masonry, or other structures, shall be classified as foundation excavation under the following heads: Dry foundation excavation, material of whatever nature, excepting solid rock, found above water level; rock foundation excavation, material, elsewhere defined as solid rock, found above water level; wet foundation excavation, all material below water level.

By "water level" is meant the average or mean level during construction at which pumping or bailing becomes necessary in the work of excavating. The quantity of wet excavating shall be computed as a prism having a height equal to the distance between the average level of the bottom of the foundation pit and the water level and a base equal to the area of the foundation course plus 4 ft. all around. The dry and rock excavation quantities shall be computed on a base equal to the bottom area of the wet excavation as above defined, with the necessary slopes to the natural surface.

Wet excavation shall include the cost of excavating, piling, coffer-dams, pumping, bailing, leveling off the bottom, and the expense, of whatever nature, necessary to complete the foundation pit from low-water level to the level finally determined for the bottom, and to maintain the foundation pit open until the structure shall have been placed therein, not, however, including the placing of iron, timber, or piles, in permanent artificial foundations, these items being paid for under a separate schedule elsewhere described.

The prices for all classes of foundation excavation shall include the cost of removing the spoil, and depositing it in adjoining fills, or of wasting the spoil, if such deposit in fills be not required by the engineer; and also the cost of removing such portions of coffer-dams as the engineer may require, for appearance or for reducing obstruction to the waterway.

Mr. Dennis is opposed to the use of the prismoidal formula. Neither this method nor that of averaging end areas gives absolutely rigid measurement. Decision must be made as to which approximation is to be taken. Averaging end areas is simple, quick and natural in principle, easier to apply, has the sanction of custom, and is on the whole fairly exact. Any reasonably experienced man will locate sections sufficiently close together on rough ground to reduce the theoretical error of the end-area computation to a small percentage.

The use of "corrections" to approximate end-area computation to the prismoidal formula appears to be still more objectionable, not having the alleged rigid accuracy of the prismoidal formula, and, as far as the writer can see, requiring nearly as much extra work, with very free chances for error. Any use of the prismoidal formula in construction computation is unwarranted as a matter of right, and very wrong as to policy. The contractor will surely put it down to "skinning," although the only motive may be a desire to be more scientific than others.

In the cost of excavation many requirements are frequently included which do not properly belong there, such as fencing right of way during construction, maintenance of road crossings, temporary bridges, saving and piling rock, opening "horseback" roads, etc. The specifications appear to assume that their cost is considered and added to the excavation prices; but the quantity of excavation is rarely known accurately in advance, and, generally, the extent and amount of the extra requirements are absolutely unknown.

The general rule of business should apply here. Where a definite thing is to be done, it should be paid for directly. Matters problematical in extent should not be called for, except with the promise of definite reimbursement. A simple, direct way is to pay stipulated prices if these matters are wanted; or, in lieu of that, to pay for them as extra work.

The survival of an error which once gets into print is well illustrated by the frequent specification: "Embankments must be carried up in layers of 2 ft."; "materials shall be deposited and distributed as the engineer may direct." The absurdity of depositing in 2-ft. layers is well illustrated by considering steam-shovel work. It is believed that this requirement, in actual expense and delay, would mean that the dumping expense alone on heavy earthwork might cause an extra cost of more than the contract price.

These requirements in railroad construction are for things absolutely without any practical value; they are unmeaning when not enforced, and a dead expense when required, and should be eliminated. On the occasions when such requirements are really necessary, the fair way is to pay for them, and not try to get them done for nothing under a blanket clause.

The remarks as to specific compensation apply partially to clearing, grubbing and overhaul, but the latter are more definitely ascertainable by the contractor before bidding. On new lines, generally, there is often insufficient information and time for minute examination. Relocation of the line and grade frequently destroys any calculation.. With no price for these items, where is the equity between the company and the contractor where extensive changes are made during construction?

The author admits that there is complication in the overhaul question, arising from what is a proper overhaul distance to specify. A 1,000-ft. overhaul on steam-shovel work may be immaterial, but it is a very serious matter for team haul. The difference could be taken up by specifying that locomotive overhaul price shall apply beyond a certain distance, and on team overhaul beyond a shorter distance. On work which, by reason of location, small magnitude, or for other cause, naturally requires hand or team appliances for excavation, the overhaul price would be made for these appliances, and would generally be high enough to require wasting and borrowing before the proper limits of steam-shovel haul were reached. Where steam shovels, wholly or in part, are anticipated, the overhaul price will come down to such an extent that there will be no controversy as to appliances, because it will be uneconomical to make any team overhaul for the price of locomotive overhaul. In sections where scrapers are the ruling appliances, specifications give properly low limits for the commencement of overhaul—300, 500 and 600 ft.; 1,000 ft. is common elsewhere, and, occasionally, 1,500 and 1,600 ft. For team appliances, 1,000 ft. is too high; 1,500 ft. entirely unreasonable.

There is considerable difference in the practice of estimating overhaul, and confusion as to just what it means. The customary meaning of overhaul is, that every yard of material moved, over and beyond the free-haul distance, is subject to the contract allowance for overhaul. To avoid controversies, the method of measuring overhaul should be stated clearly so that the contractor, in bidding, could cover the ordinary hauls, as well as the special hauls called for by exceptional conditions. The simplest method would be to locate the stations of free haul, and then deal with the cut and fill on either side by locating the station of the center of mass of each.

It is as usual to see agreements specify that no work is to be sublet as it is to see, in the execution, sub-contractors more or less peacefully performing their assigned tasks. What is the purpose of the prohibition? It is generally a dead letter in the enforcement. The sub-contractor exists because his services in detail, as foreman, manager or contractor, coupled with his financial interest in results, and his special plant, are at times more efficient than can be obtained in other ways. The only objection that can be brought seriously against the practice is in case of failure, or litigation on account of the sub-contractor; but. in this case, under any customary contract, the company still holds the contractor for the financial end.

The most reasonable view is not to prohibit a perfectly business-like arrangement, but frankly admit it, and, in admitting it, control the form. A stipulation that would seem to cover the whole case would be to require the sub-contractor's agreement to read something like this:

"The company and the contractor shall have all rights and power as to the sub-contractor, that the company has as to the contractor, in its contract with him; and the work assigned to the sub-contractor shall be done subject to all the conditions stated in the specifications of the company, or embodied in the contract between the company and the contractor."

As the more successful sub-contractors become contractors and then competitors, the only people really interested in opposing them are the contractors themselves. They might be said to be

opposed to subletting work as a principle, but in actual practice they find that, for portions of their work, the arrangement is the least costly and most efficient method of producing a certain result.

One of the scandals of railroad construction is the absolute disregard of plain business methods in the acquisition of right of way, and the consequent unfair saddling of useless expense on the contractor. It is a notorious fact that, in general, the construction contract is let with little or none of the right of way secured. The contractor sometimes gets on the ground before the right of way agent. That agent's interest is to get right of way for the least money. He may consider that a $20 difference may justify withdrawal for a month, or throwing the case into court in order to sustain his prestige. He is held responsible for the results, has a hard job, and must play all the politics he knows. From his standpoint, his action may be right. Suppose the contractor is held up at a critical point of the work; the other's right is not right for him. His contract says he must wait the other's convenience, whether he likes it or not, and shall lose the time and expense of waiting. This is a daily occurrence.

All agreements are elaborate in provisions to save the company harmless against any acts of the contractor during construction. These provisions are proper, provided the contractor is legally liable; they are wrong where the company withholds payments to force the contractor into settlements, whether proper or not. Many agreements recite that in the event that the company is a party to the action, the company may settle without the consent of the contractor and charge against him, together with such legal expenses as the company may choose to fix as its cost of defense.

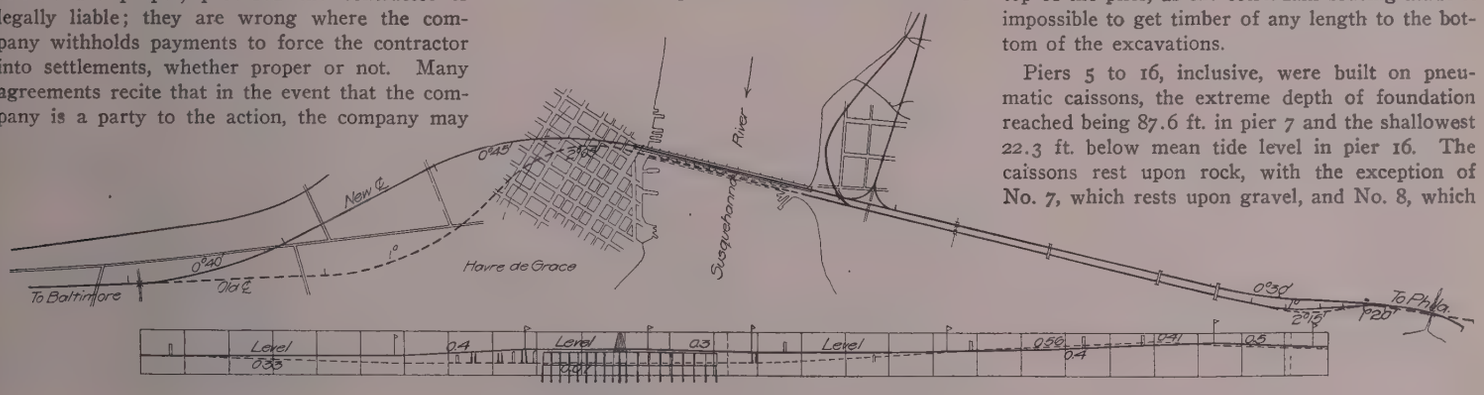
Mr. Dennis can see no fair ground why the company should be more favored in the case of construction contracts than in any of its other agreements where it takes its chance according to the general law. The fair principle is that, if the railroad pays the contract price, it should get the goods; if the contractor incurs liability, then, by agreement, he should indemnify the company against loss, and the obligation should end there. In accepting the contractor, the company should consider his ability to save it harmless, just as it considers and accepts his ability to perform the work. If the company is sued jointly with the contractor, it may either let the contract or defend, looking to his satisfying any decision, or, if it elects to defend also, it should do so at its own expense, as it would in any other action.

It is safe to say that in no other business relation between men are such one-sided agreements customary; in no other relation is a man conceived to be clothed, by reason of a written instrument, in a mantle of infallibility, as is the engineer in customary railroad contracts. In political matters, some thinkers hold that an intelligent despot can give the most efficient government; so, in the case of the engineer, granting an untrammeled, industrious and able man, subjecting the contract to his exclusive decision may work out as the best arrangement all around. The objection comes, not so much from arbitrary or unfair use of the engineer's power, but from his carrying out, or being forced into carrying out, requirements which are too broad or are unreasonable.

In conclusion, Mr. Dennis' main thought in this whole discussion is: That a contractor and a company enter into an agreement for mutual benefit. Every matter not clear, subject to whim and opinion in its working out, unfair in its intent, or in the nature of a "strangle hold," is unfair to one side and reacts upon the other, and that the business of both parties is best served by a fair agreement.

The Pennsylvania Railroad Improvements Between Philadelphia and Baltimore.

The Pennsylvania Railroad is now rapidly completing portions of the vast improvements it entered upon a few years ago, and the company is already beginning to reap its reward in earnings, due to lower operating cost and improved service, both freight and passenger. An important link in this chain of betterment is the practical making-over, recently completed and placed in service, of that section of the main line of the Philadelphia, Baltimore & Washington R. R. centering at Havre de Grace, Md., at the mouth of the Susquehanna River and extending about 5½ miles, from Principio to Oakington.



Old and New Alignments and Grades at Havre de Grace.

The principal feature of these improvements is a new steel and masonry bridge, about a mile long, over the Susquehanna River at Havre de Grace, Md. This bridge was built in fast time and embodies many interesting features. The other changes were in line with the established policy of the Pennsylvania R. R. to eliminate grade crossings, and reduce grades and curvature wherever possible. These improvements mark another step in the plans of the company eventually to reduce the running time between New York and Washington to four hours without sacrificing safety. With this work completed, the main line of the Philadelphia, Baltimore & Washington between these stations has four tracks, except over the Susquehanna Bridge, which carries two. Not a grade crossing has been left, grades are reduced, and curvature is now at a minimum. The road has been built to serve its purpose at a small cost of maintenance, for an indefinite period of time.

The improvements center in the large bridge at the mouth of the Susquehanna River, which is located about 150 ft. north of the old structure. The new bridge contains 44,369 cu. yd. of masonry and 20,230,384 lb. of iron and steel, and consists of seventeen fixed deck spans and a through draw span 280 ft. long. The first fixed span on each end is 196 ft. 6 in. long; the remaining spans on the Havre de Grace end are each 200 ft. long, and on the Perryville end 260 ft. long from center to center of piers. The fixed spans have a clearance of 24 ft. 3 in. at mean tide, and the draw span 53 ft. at mean tide. When opened the draw presents a clear opening of 100 ft. on either side for the passage of vessels. The details of the steel superstructure were illustrated in this journal on April 28, 1906.

The bridge rests upon 20 piers of Alleghany Mountain sandstone, with concrete backing and Port Deposit granite coping. They are at right angles to the bridge, with the exception of the two rest piers for the draw, which are swung 14 deg. to the west to bring them in line with the current of the river. Pier 1, the east abutment, was built by open cofferdam construction on rock at an elevation of 4.4 ft. above mean tide level and the excavation for piers 2, 3 and 4 was carried on by the same method, in the case of pier 3 a depth of 32.0 ft below mean tide being reached. From the bottom of the excavations piles were driven to solid rock. In the case of pier 2 294 piles were driven until their points were 77.0 ft. below mean tide, and piers 3 and 4 each rest upon 390 piles driven until the points reached an average depth of 110.0 and 88.0 ft., respectively. The piles were all driven with a steam hammer, and followed below the top of the cofferdam by means of extension leads to the pile driver. They were sawed off and capped with concrete for a depth of 2 ft. below and 6 ft. above the heads. It was impracticable to put a timber grillage on top of the piles, as the cofferdam bracing made it impossible to get timber of any length to the bottom of the excavations.

Piers 5 to 16, inclusive, were built on pneumatic caissons, the extreme depth of foundation reached being 87.6 ft. in pier 7 and the shallowest 22.3 ft. below mean tide level in pier 16. The caissons rest upon rock, with the exception of No. 7, which rests upon gravel, and No. 8, which rests upon gravel and boulders. It was the intention to build piers 14, 15 and 16 by the open cofferdam method, but the idea was abandoned in the case of Nos. 14 and 15 because there was so little sand and mud where the piers were located, while in the case of pier 16 it was not given up until a month was spent trying to put in a cofferdam and prevent its leaking. Piers 17, 18 and 19 and the west abutment were built on rock in open cofferdams, the greatest depth being 17.2 ft. below mean tide level. The fender at the draw is built of piles with a granite pier at the north end and a timber crib filled with stone at the south end. The granite pier rests upon a caisson sunk to a depth of 44.8 ft., while the crib rests on the river bottom dredged to a depth of 30.5 ft. below mean tide level.

Work was started upon the piers in the summer of 1904, but not much river work was done until the ice went out in 1905. The last masonry was laid on the fender pier Dec. 16, 1905. Erection of the steel work was begun Aug. 10, 1905, and finished May 22, 1906. The draw span was erected on falsework over the fender and swung into position May 19, 1906.

Two bad curves are eliminated south of Havre de Grace, there being a 2 deg. 5 min. curve to the left 2,626 ft. long, followed by a tangent 400 ft. long, and then a 1 deg. curve to the right 4,537 ft. long. To offset this curvature on the new line the following curves have been used: A 45 min. curve to the left 4,338 ft. long, then a tangent 3,847 ft. long, followed by a 40-min curve to the right, 3,655 ft., which then returns to

the old line. There is one other curve on the line, near Principio, a 30-min. curve to the right, 1,600 ft. long. On the old line near this point there is a 1 deg. curve to the right 1,600 ft. long. In making the changes upon the main line, the junction with the Columbia & Port Deposit R. R. (a branch of the P., B. & W. R. R.), was thrown 1,200 ft. north at Perryville. This necessitated making alterations for about 8,550 ft. and running into the old line north of Frenchtown station.

All grade crossings on the main line are eliminated for this stretch of 5½ miles, and two out of three crossings on the C. & P. D. branch are now made with undergrade bridges. In all 14 bridges or openings, the largest of 35 ft. span, have been built for small streams and roadways.

The change of line (excluding the river bridge) involved the use of 30,000 cu. yd. of masonry and necessitated 745,000 cu. yd. of excavation. The masonry is all of Alleghany Mountain sandstone with granite bridge seats.

Sewage Filtration in Winter.

The maintenance of the Brockton, Mass., sewage filters in winter was described at a recent meeting of the sanitary section of the Boston Society of Civil Engineers by Mr. George E. Bolling. The experience with level filter beds during the first winter that the plant was in operation was not satisfactory, ice freezing to the surface of the beds and lowering their efficiency. Since that winter the beds as a rule have been furrowed, the object being to have the ice which is formed rest on the tops of the ridges, and thus keep from attaching itself to the whole surface of the bed. The ridges are 3 ft. apart and 12 in. deep.

Frost cannot be kept out of the furrows, and in a winter of ordinary severity penetrates down into the bed 8 or 10 in. below the bottom of the trenches. This frost line is comparable with a water table, conforming to the configuration of the surface of the ground, the unfrozen sand being nearer the sewage under the ridges then under the furrows. As the strength of the sewage increases and the sediment presents an almost impervious layer, much of the absorption into the body of the filter takes place diagonally downward through the sides of the ridges.

On the application of a dose of sewage to a bed in winter, Mr. Bolling said, absorption does not take place until the warmth of the sewage has thawed a path for itself along the line of least resistance. While this is occurring and there is no settling of the sewage a sheet of ice forms on the top and when subsidence takes place this ice is supported on the top of the ridges, affording an additional help in conserving the heat of additional doses applied to the bed. The use of furrows also conserves the heat of the sewage by exposing less of the surface to the cold than would be the case in a level bed.

Only one level bed has frozen over completely, which is attributed to the fact that the subsoil had not been removed. Another level bed in which the subsoil had been removed was operated continuously through a very severe winter. During one winter ice formed in the bottom of the furrows of nearly all the beds, though not over the entire area. The ice started around the edges in the sediment remaining in the furrows, and then filled the whole section of the furrow as repeated doses were applied, until in some cases a third of the bed was frozen solid, and became unavailable for filtration purposes.

For about eight years the application of sewage to furrowed beds during the winter months was followed by the proper subsidence of the sewage, within 4 to 48 hours, leaving a dry bed ready for the next dose. After this time the gradually increasing quantity of organic matter in the upper 6 to 8 in. of the beds had reached an amount where a clogging occurred that would not permit the absorption of the sewage until such a depth was put on the bed as provided a sufficient head to force the sewage through the clogging material. The depth required for this purpose was from 0.5 to 1 ft. above the top of the ridges. Even with this clogging, the quality of the effluent remained good.

It was necessary during a few successive spring cleanings, in order to get at the surface of the beds, to facilitate the absorption of the supernatant sewage accumulated during the winter by raking the clogging material. This was necessary in order that it might be absorbed before the increasing warmth of the spring produced a nuisance. The raking cost from $3 to $10 per bed. This cost has been largely eliminated the last few years by cleaning one or two of the lower elevation beds, and drawing off on to them the supernatant sewage of the higher beds.

Seven new beds constructed in 1905 were dosed on an average every third day, and sometimes every second day, the doses being about 135,000 gal. per acre. The beds dried after each dose; the flat beds average 7 hours for absorption, and the furrowed beds 8 hours.

In the summer of 1905 an attempt was made to remedy the slow absorption of sewage in nineteen beds by removing 6 in. of the surface material. In all 16,400 cu. yd. were removed at a total cost of $4,314.36. The material removed varied in organic matter, from 0.7 to 4 per cent by weight, and in organic nitrogen from 90 to 280 parts in 100,000. This removal quickened the absorption during the summer, but had apparently no effect during the winter, though the latter fact is partly due to the increase in the strength of the sewage.

This accumulation of the sewage upon the beds in winter has not worked to any permanent disadvantage. The analysis of the effluent from these beds differs but little from what it was when the beds became completely dry between doses. The analysis of the effluent of one of the beds in April, 1905, when it was at its worst, showed a purification of free ammonia, albuminoid ammonia, oxygen consumed, and bacteria of 51, 91, 69 and 66 per cent. respectively, while in September after the usual summer cleaning the percentages of purification in the order named above were 99.8, 99.5, 97 and 99.99+. Many of the winter effluents, while appearing only slightly turbid at the time of collection, deposited a copious precipitate of iron which rendered them very unsightly after standing. This iron is derived from the soil of the filter beds and its solution in the effluent is facilitated by the amount of organic matter the winter effluents contain. Effluents carrying as much iron as 12 parts per 100,000 are not uncommon in winter. The quality of the effluent improving as the summer advances, the iron gradually grows less in amount and finally ceases to be apparent.

The average cost of furrowing beds and finishing them is $5.21 per acre, and of preparing the level beds, $5.19 per acre. The flat beds are more easily cleaned, but it may be questioned whether the efficiency of the furrowed bed is not materially increased by removing more of the material which has a tendency to clog the filter. The full paper, from which these notes have been taken, together with the discussion it drew out, will be found in the "Journal" of the Association of Engineering Societies for January.

Block Signals in New York.

The block systems on the New York railroads will have to be improved if the Board of Railroad Commissioners is able to have its way. In a recent letter to all companies in the State, the following comments are made: "The method now used on very many roads of spacing trains, or the permissive block system which allows more than one train in a block at a time, under cautionary orders, is not shown to be effective. A heavy train may make slow progress; a lighter one, even if held five or ten minutes at a telegraphic station, may overtake the leading train and collide with it. Also in the permissive block system a train enters the block and the men are too apt to consider that they are protected and do not flag promptly. Also another train entering the block under cautionary orders is too liable to assume that the first train must be out of the way by that time and does not proceed as cautiously as it should, and collisions result. We are aware that at terminal stations and large yards it will in some cases be necessary to permit more than one train at a time in such blocks; but those blocks should be made as short as they can consistently be made and the restrictions governing movements in them be made promptly and rigidly enforced. We are of the opinion that permissive blocks should not be operated, and we recommend that all steam roads where the permissive block system is in operation install sufficient additional block signals at the earliest possible moment."

New and Old Bridges Over the Susquehanna River at Havre de Grace.

The Manchester Ship Canal yielded gross receipts of $1,292,834 during the last six months of 1906, and required an expenditure of $634,124, according to a United States Consular Report based on the canal company's semi-annual statement. The profits of the Bridgewater department were $74,295. With some other minor additions, the balance carried to net revenue account was $738,300. The results of the half-year's working by the canal department, as compared with the last six months of 1905, was an increase of $121,463 in receipts and $19,500 in expenditure, leaving a gain of $101,963 in the profits. The seaborne traffic during the six months of 1906 was 2,328,428 tons, 200,924 tons more than the traffic of the corresponding six months in 1905. The traffic on the canal shows a steady increase from 686,158 tons in 1893, when it was opened to traffic, to 4,441,241 tons in 1906.

The Hydro-Electric Plant of the Towaliga Falls Power Co., Griffin, Ga.

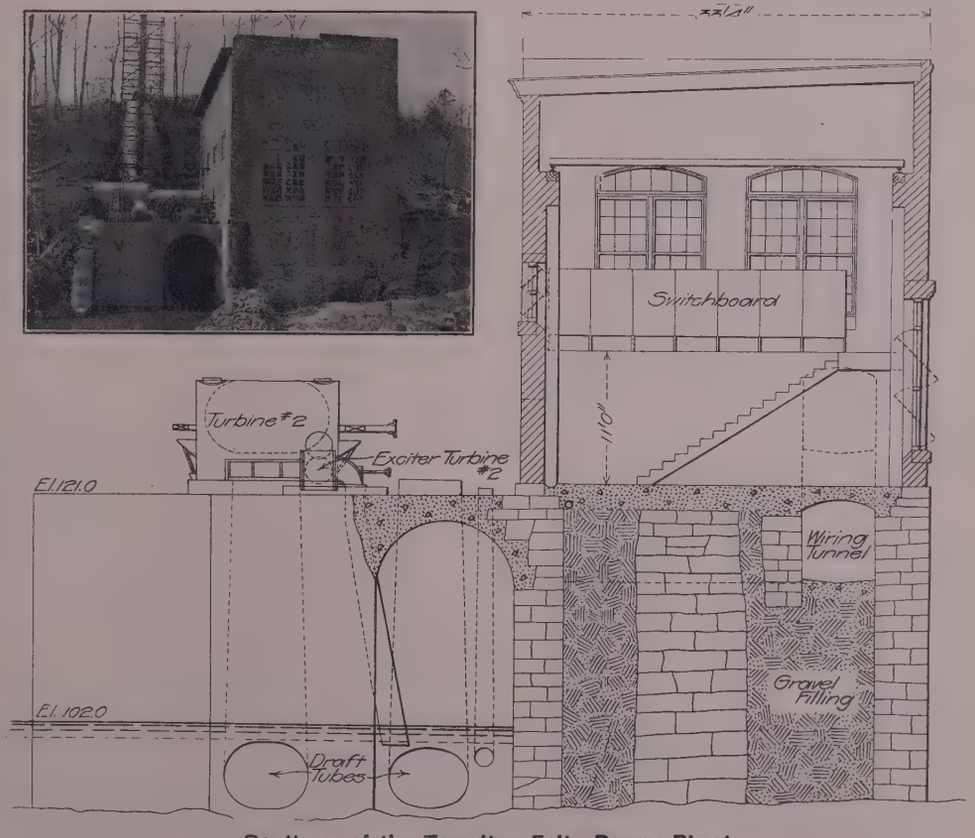
An interesting water power development has recently been completed on the Towaliga River by which some 3,000 h.-p. are rendered available from a stream having a minimum flow of about 100 second-feet. The Towaliga River is a small stream originating near Griffin, Ga., some forty miles southeast of Atlanta, and flows in a southerly direction into the Ocmulgee River. It has a drainage area of some 250 square miles, and at a point about 15 miles east of Griffin, it has a natural fall of 110 ft. in a distance of 2,000 ft., with at one point in this distance, an abrupt drop of about 60 ft. In 1902 the Towaliga Falls Power Co. was organized for the purpose of developing this water power, the power to be utilized for the operation of some large cotton mills located at Griffin which had formerly been driven by steam power.

The water power rights were secured at Towaliga Falls and careful topographical surveys of the water shed were made, as a result of which plans were made for the development of 3,000 h.-p. under a 110-ft. head, by the use of a 25-ft dam. The dam was decided upon principally for the purpose of creating a large storage reservoir to tide over the 30 to 60-day periods of low water which frequently occur in the fall of the year. These periods of very low flow do not occur every year, not having appeared last fall nor in the fall of 1901, but occur with sufficient frequency as to make this storage necessary in order to permit of the continuous development of power to the extent of 2,000 h.-p. The topographical conditions at the falls proved very favorable for impounding a large volume of water, the country lying immediately above the falls, consisting of a wide, flat valley. As a result of the construction of the dam, an area of 800 acres is flooded and the water is backed up some ten miles. The amount of storage available is approximately 350,000,000 cu. ft. when the pond has been drawn down 15 ft., which is the level of the water in the canal. This amount of storage provides for the use of about 300 cu. ft. per second for 66 hours per week (the operating time of the cotton mills) and is sufficient to develop 1,362 h.-p. on the wheel shaft of each of the two units.

At the point selected for the dam, the Towaliga River passes over a solid ledge of granite which afforded most excellent foundations for such works, it being, in fact, necessary to do but very little work in preparing foundations for the dam. The granite of which the dam is built was quarried at either side where the dam ties into the hills, and there were large quantities available and of very good quality. As the river was quite shallow, very little coffer-damming was necessary, and during a period of low water, the foundation work was rushed through and completed; subsequently, very little trouble was experienced with high water. The dam is built of large, rough blocks of granite with good beds laid in mortar and placed about 9 in. apart, the vertical spaces being filled with concrete. American Portland cement was used on all the work, in the Atlas and Lehigh brands. As shown in the cross section of the dam in the accompanying drawing, the roll-way is so proportioned that the flood waters in passing over are in contact. It is 27 ft. in height, 24 ft. wide at the base, and has a total length of about 300 ft. In the south end a bulkhead is built in which are placed four gates, two of which discharge to waste into the river and two are for supplying the canal or flume. These gates are built of cast-iron and are operated with ball bearing hand lifts, furnished by the Coffin Valve Mfg. Co., of Boston, Mass.

The flume ofrom the dam to the power house is about 1,000 ft. long, and is constructed on the hill sides at one side of the river. The first 800 ft. is located on the granite ledge and it was necessary to build a masonry wall along this section to cut it off from the river. The remaining portion was made by excavation from the hillside where the formation is of red clay, which was used to form an embankment. This material was carefully selected and thoroughly puddled, and at one or two points the embankment is 20 ft. high. The cross section of the canal is sufficient to pass 500 cu. ft. per second at a velocity not exceeding 3 ft. per second.

At the lower end of the canal a masonry bulkhead was built for supporting the steel trash racks and head gates—which admit the water to the steel penstocks which lead down to the wheels at a lower level. Two of these penstocks have been provided for, one 11 ft. in diameter and the other 7 ft. They are 350 ft. long, dropping 85 ft. from the flume to the level of the wheels. Only the 11-ft. penstock has, however, been installed, having been built of tank steel plates, varying in thickness from ½ in. at the lower end to 5/16 in. at the upper end, and furnished and erected by the Hartley Boiler Works, of Montgomery, Ga. It is supported on concrete foundations throughout its entire length and firmly anchored at the lower end. On the upper end of the penstock, there is an air pipe 30 in. in diameter to free the pipe of air pockets, and on the lower end, a standpipe is erected 48 in. in diameter and 90 ft. high to provide for fluctuations of pressure in opening and closure of gates. The lower end of the penstock is sub-divided into two branches each about 8 ft. in diameter, as shown on the accompanying drawing, which are connected to the wheels. The wheel connections can be cut off by means of a steel gate placed immediately in front of the wheel cases, and operating in such a way that when the gate is open it slides down into a steel pocket built into the masonry foundations; by this arrangement the gate and mechanism is always entirely out of the way.

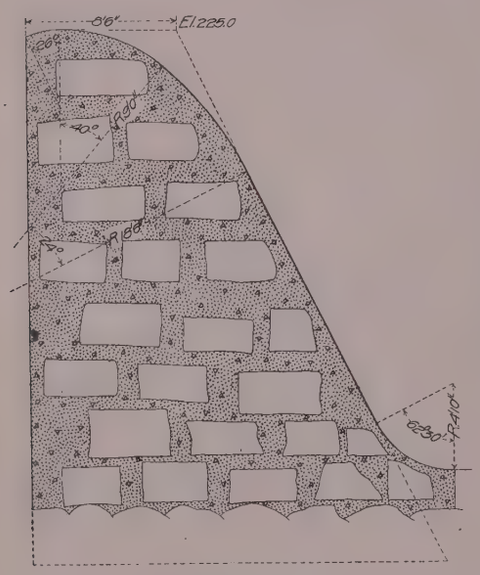


Sections of the Towaliga Falls Power Plant.

These gates are furnished by the Holyoke Machine Co., of Worcester, Mass.

As will be seen in the drawings, the wheels are located outside of the power house on a concrete platform 19 ft. above tail water level, and are arranged to discharge into the tail race by means of draft tubes built into the concrete construction. With this arrangement it was possible to build the power house on a solid granite ledge which terminated abruptly on the side where the wheels are located, thus affording an economical location. The power house is built for three water-wheel units, only two of which have, however, been installed. One wheel, furnished by the James Leffel Co., Springfield, Ohio, is a special horizontal center-discharge Samson turbine with a pair of 26-in. wheels, which under a working head of 108 ft. and running at a speed of 514 r.p.m., will develop 1,500 h.-p. at a guaranteed efficiency of 80 per cent. A horizontal single discharge 13¼-in. Samson turbine is also installed connected to the casing of the larger wheel which drives one of the exciter units. This wheel is guaranteed to develop 100 h.-p. at 975 r.p.m. and at 80 per cent. efficiency. Both units are built in steel casings.

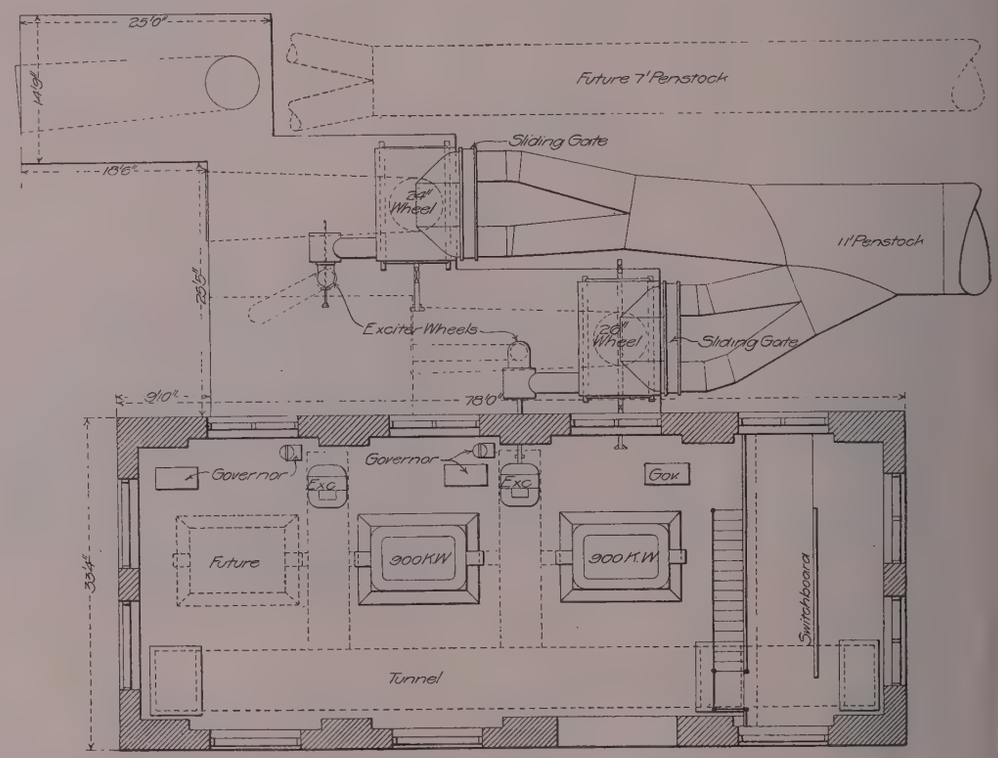
The other water-wheel unit was furnished by the Holyoke Machine Co., of Worcester, Mass., and consists of a horizontal center discharge special Hercules turbine with a pair of 24-in. wheels, the runners of which are of manganese bronze.



Section of Dam.

15-ton hand-power crane furnished by the Reading Crane Works, Reading, Pa.

In the building is housed the electrical generating equipment which consists of two 900-kw. three-phase, alternating-current generators and two 50-kw. exciters, each generator direct connected to its driving-wheel by shafts extended through the side wall. The large machines are supported on heavy masonry foundations carried down to bed rock, the wiring passages under the floor passing along the opposite side with branches extending across between foundations. The governors for the wheels are also located within the building where convenient for driving from the shafts. The large generators are of the revolving field type and are operated at 514 r.p.m., being wound to deliver three-phase alternating current at a frequency of 60 cycles and potential of 13,500 volts at normal rating. The design of the generators is such, however, that the e.m.f. may be raised to 15,000 volts if it is desired to make use of this higher voltage. The regulation is without the aid of compound winding, and is



Plan of the Towaliga Falls Power Plant.

merely an oil switch control with transformers and tripping device and two ground detectors. The entire electrical equipment including both generators and switchboard were built and installed by the Stanley Electric Manufacturing Co., Pittsfield, Mass.

The transmission line from the power plant to the sub-station in Griffin is 15 miles long, and most of it is located apart from the public highway on the company's private right-of-way. There are but few angles in it, the route having been laid out in almost an air line. The poles are of cypress, 35 ft. long, and not less than 7 in. in diameter at the small end, and have been set 110 ft. apart. They were carefully treated with carbolineum, before erection, and are set 5 ft. in the ground. There are four cross arms on each pole, two for the high-tension circuits, one at the top of the pole for the two iron wires connected to the ground and one for the telephone circuit. There are to be two three-wire transmission circuits, one on each side of the poles, but only one has as yet been erected. It

These wheels are guaranteed to develop 1,680 h.-p. at 514 r.p.m. with an efficiency of 80 per cent. A horizontal single discharge 12-in. Hercules turbine is also attached to this wheel to drive an exciter unit which is guaranteed to develop 100 h.-p. at 975 r.p.m., and 80 per cent. efficiency. They are both built in a heavy steel casing. The governors for controlling the speed of the large wheels are the improved pneumatic governor, built by the N. Lombard Improved Governor Co., of Worcester, Mass. The governors controlling the speed of the exciter wheels are the type D governor of the Woodward Governor Co., Rockford, Ill.

The power house is a one-story brick building with wooden roof and is 78 ft. 8 in. long by 33 ft. 4 in. wide. The walls are laid on masonry foundations and the floor is of concrete, the level of the latter being raised at one end 11 ft. to form a switchboard gallery. An under-floor connection is made from this gallery to the generator room by large conduits built under the floor which provide for all the cables and wires leading from generators and exciters to the switchboard. The entire construction of the building is very substantial and the floor is spanned by a

such that when full load is thrown off, the voltage will not rise above 14,310 volts and at a 90 per cent. power factor and full load, regulation is within 16 per cent. The commercial efficiency is 94 per cent. at full load, 93 per cent. at one-half load, and 90.5 per cent. at one-quarter load. The generators require but 10 to 14 kw. for excitation so that each of the 50-kw. exciters is sufficient for the two alternators at present installed and also the future unit. The exciters are multipolar compound wound generators operating at 875 r.p.m., and are wound for 125 volts.

The switchboard equipment at present installed consists of two generator panels, a panel for the transmission line, and an exciter panel. It is built of blue Vermont marble with 42x66-in. panels supported on an angle iron frame. The equipment of each of the generator panels consists of a remote control for a three-pole oil switch with circuit breaker attachment, field switch and rheostat, two indicating watt-meters, two ammeters and a volt meter and synchronizing apparatus. The exciter panel contains two ammeters, a volt meter and the necessary rheostats and switches for control and operation in multiple. The transmission line panel contains

consists of three No. 00 copper wires strung on heavy porcelain insulators, each tested up to 50,000 volts. The wires composing this circuit are transposed at three different points in the line. The ground wire circuit is composed of two No. 6 iron wires, connected at every fifth pole by a wire of similar size running down to a large heavy plate of galvanized iron buried 5 ft. in moist soil.

The sub-station at Griffin is a one-story brick building built quite near the plant of the Griffin Mfg. Co., which is probably the largest consumer of power. It contains seven water-cooled oil transformers, each of 300 kw. capacity, and a single panel switchboard. The transformers are designed for stepping down from 12,000 volts to 2,200 volts, and have 97½ per cent. efficiency at full load and 96½ per cent. at half load. The switch panel is 36 x 66 in. in size and contains the remote control of a 100-amp. oil switch with automatic circuit breaker attachments, indicating voltmeters and ammeters, and a ground detector for the low voltage distribution lines. For protection from lightning there is an equipment of three straight-gap arresters at both the power house and the sub-station.

The cotton mill of the Griffin Mfg. Co. has been one of the most successful mills in the South and has just completed a 10,000-spindle addition, built and equipped for the electrical drive. The entire plant is now driven by power furnished from Towaliga Falls, amounting to about 1,000 h.-p. The mill is equipped with Stanley induction motors, of which there are some 10 or 12 in use, and most of them are inverted and suspended to the ceiling, either direct connected to line shafting or driving it by belts. This mill has been driven electrically a little more than a year, and has proven very satisfactory. The plant of the Kincaid Mfg. Co., another large and successful cotton mill, is also being equipped for electrical driving, and when in operation will require about 600 h.-p.

There are also a number of smaller consumers in Griffin using power from the falls and making applications for it, so that the Power Company will soon have sold their entire output. If the third unit is installed an extra 1,000 h.-p. will be sold only as secondary power, the right being reserved by the Power Company to cut off the secondary power when the water in the river may be found to be insufficient to operate this unit.

The Towaliga Falls Power Co. was organized in 1902 with Capt. S. Grantland, president, Mr. W. J. Kincaid, vice-president, and Mr. James M. Brawner, treasurer, all of whom were largely interested in cotton mills at Griffin which had been operated by steam power. The introduction of the cheaper and more desirable power was due largely to the untiring efforts of Capt. S. Grantland, who purchased the principal part of the water power several years ago, and has furnished probably one-half of the necessary capital to build the plant. The company under his management, bought tools and equipment and did all the construction work. The engineer retained for the design and construction of the plant was Mr. William C. Whitner, of Richmond, Va., and Rock Hill, S. C. During construction, Mr. W. Gatewood Adams was resident engineer until the fall of 1904, when he accepted another position, and was succeeded by Mr. C. L. Reid. Mr. Samuel Cunningham, of Griffin, was superintendent of the company's forces during the construction of the construction work.

Sprinkler System of Fire Protection in the Claflin Store Building, New York.

The Claflin Building is a ten-story and basement structure of steel and brick, on 34th St. near Fifth Ave., New York City, the heating and ventilating equipment of which was described in The Engineering Record of Feb. 23. The building extends 200 ft. through the entire block from 34th to 35th Sts., and has a frontage of 150 ft. on both streets. It is occupied solely by the department store of James McCreery & Co., the basement and all floors to the eighth being devoted to retail departments; a portion of the basement and eighth floors and the entire ninth and tenth floors are devoted to the auxiliary service of the store, including shipping, altering and repair departments, locker and lunch rooms and offices, while the mechanical plant is in the sub-basement.

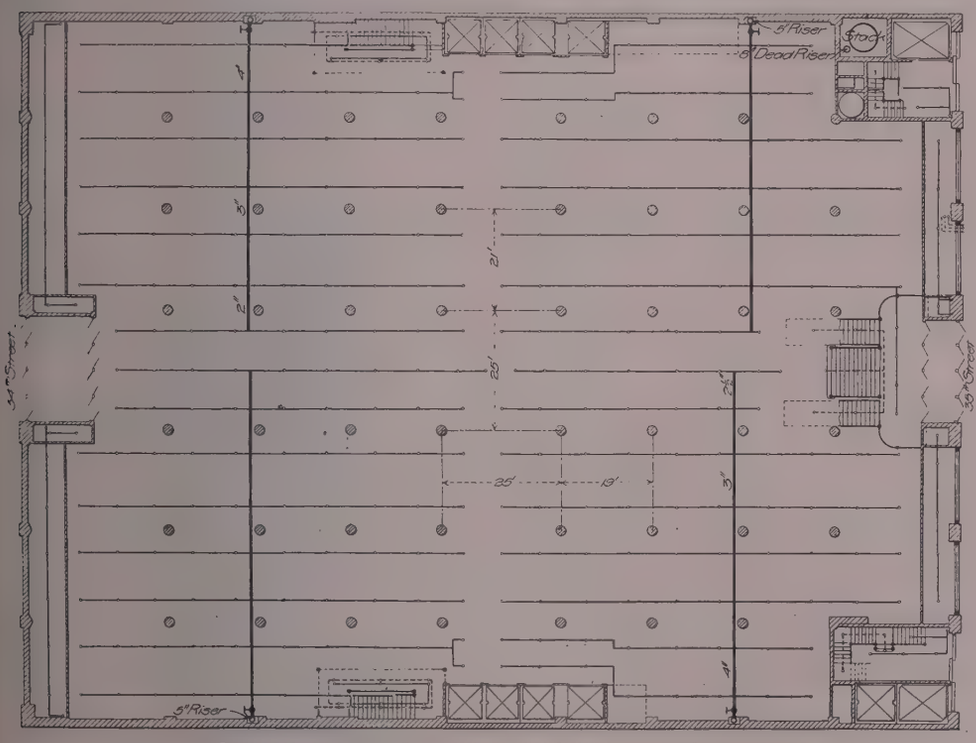
The building was constructed with special reference to the requirements of the underwriters for protection from fire, there being little combustible material in the structure. It is laid out on what is considered an ideal arrangement for retail store purposes, each floor consisting of a 150 x 200-ft. open space, unbroken by partitions. Access from floor to floor is had by groups of elevators enclosed in wire-glass partitions, at the mid-points of either side wall, and by four enclosed stair-wells, two at the rear corners of the building and one on either side toward the front. There is, in addition, an open stairway communicating between the retail floors in the rear central portion of the building, which is the only open communication from floor to floor. By the enclosure of elevator shafts and stair-wells and conformity of all other details of the building construction to the underwriters' requirements, a very low insurance rating was secured on the building. Owing, however, to the combustible nature of the goods carried, additional precautions were thought desirable, and a sprinkler system was accordingly designed with special reference to the conditions in the store. As a result of all these precautions, the building and its contents have received a 47½ per cent. insurance rating from the New York Fire Insurance Exchange. The open stairway which is carried up through the retail floors for the convenience of customers, was the only detail which prevented a 50 per cent. rating being granted.

The requirements imposed were in general that the sprinkler heads should be so distributed that each should have to cover not more than 100 sq. ft. of floor space and that the arrangement of piping should permit 25 per cent. of the heads in any floor or fire area to be supplied at one time, each with 20 gal. per minute, without diminution of pressure. The former requirement necessitated two lines of sprinkler heads in each of the 20-ft. longitudinal aisles between building columns, each line carrying two heads in each 20-ft. transverse aisle which provides four heads to each of the floor panels, 20 ft. square, between columns. Through the center line of the building, both longitudinally and transversely, the asles widen to 25 ft. on each floor and it was there necessary to install three rows of heads, each way, instead of two, in order that the space might be properly covered. In the accompanying floor plan the distribution of heads and the arrangement of the piping are indicated, which is typical of that on all the floors.

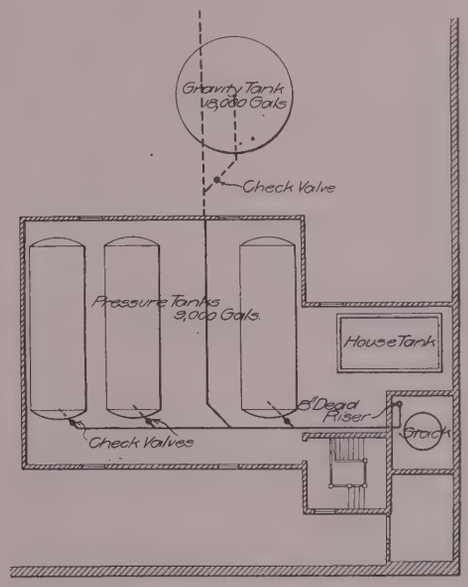
The heads on each floor are supplied in groups with water from four 5-in. risers distributed centrally in the four quarters of the building, in which pressure is maintained by roof tanks. These risers are located in chases in the side walls as near as possible to the distribution center of the quarter-sections supplied. From each riser, lateral mains are taken off near the ceiling of each floor to supply the sprinkler heads, which are mounted on branches from the laterals, extending longitudinally through the building. The lateral main from the riser begins as a 4-in. line, tapering to 2 or 2½ in. toward the center of the building. The branches carrying the heads also taper in either direction from the lateral, the sizes ranging usually from 2 or 1½ in. down to ¾ in. The sizes of all branches are carefully proportioned to prevent excessive drop in pressure if a number of heads should open. The sizes of all lateral branches were proportioned in accordance with the underwriters' latest schedule as follows:

Pipe size, in.....	¾	1	1¼	1½	2	2½	3
No. Heads.....	1	2	3	5	10	20	36

A feature of the installation is that on the first and second floors the sprinkler piping is concealed in the ceiling finish, which was done to enhance the appearance of the interior, nothing but the sprinkler heads appearing below the surface of the ceiling. This involved serious difficulties in installation, for the piping had to be carried above the 12-in. I-beams of the floor



Arrangement of Sprinklers and Piping on Main Floor.



Connections to Roof Tanks.

framing, and, as the floors are of concrete, it was necessary to complete the piping before the floor could be finished. The arrangement of piping is similar to that of the other floors of the building as to spacing of heads and sizes of laterals and branches. In the location of the shut-off valves in the laterals from the risers to the branch lines the valves were required to be entirely exposed, which necessitated special construction, as indicated in an accompanying detail. The valve is thus rendered easy of access for inspection and can readily be removed if desired.

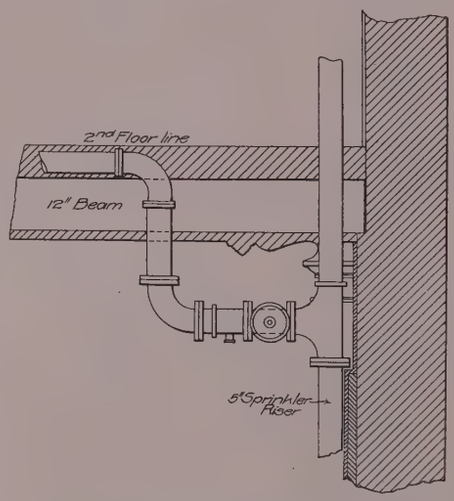
There are an average of 325 heads on each floor supplied from the four risers, which are connected on all ten floors and basement to a total of 3,865 heads. In addition, there are 16 heads in the front show windows and 10 in the rear windows, and 133 heads in the two enclosed stair wells at the rear corners of the building; these are connected to five special risers. The total number of heads in the entire building is 4,051. Each of the nine riser lines has an alarm valve which sounds an alarm and indicates on an annunciator in the engine room the riser on which the heads open. To prevent freezing, the lines in the show windows are all operated on the dry pipe system, air valves in the risers to them permitting ready flow of the water in case any of the heads open.

Water pressure is maintained on the sprinklers by a combination of two roof 18,000-gal. gravity tanks, and three 9,000-gal. steel pressure tanks in a pent house on the roof. About one-third of the capacity of the pressure tanks is for compressed air, so that they are estimated to hold about 6,000 gal. of water each. All are connected to an 8-in. pressure main running to an 8-in. dead riser extending down through the smoke-stack enclosure to the basement, where a connection is made with a distributing main of the same size. This main is carried along both sides of the building to supply the four 5-in. risers to the sprinkler mains on each floor, and it also supplies two individual risers in the enclosed stair-wells at the rear of the building, one 3-in. riser to the heads under the first floor mezzanine gallery and sidewalk vault, and two 2½-in. risers to the show-window sprinklers. Branches are also extended from the basement distribution main to siamese steamer connections outside the building at the 34th St. and 35th St. sidewalks.

Both the gravity and pressure tanks on the roof were proportioned in accordance with the underwriters' requirements that sufficient storage should be provided to permit operating a certain percentage of the heads in any floor or fire area for a period of 20 minutes. For the gravity tanks it was required that a capacity be provided sufficient to supply fully 25 per cent. of the heads in any fire area, which amounts to practically 80 heads, while for the pressure tanks about half this capacity was required. As the heads are designed to discharge approximately 20 gal. per minute, this corresponds to a discharge of 1,600 gal. per minute or 32,000 gal. in the period of 20 min., for the gravity tanks, and 16,000 gal. for the pressure tanks. Both the gravity and the pressure tanks have a capacity somewhat in excess of these quantities.

The two wooden gravity tanks are supported on steel towers above the roof at a height of 20 ft. above the highest sprinkler heads; the latter are in the pent house and their position made it necessary to raise the tanks some 30 ft. above the roof level. The pressure tanks are steel, 8 ft. in diameter by 24 ft. long, and placed horizontally in the pent house. It was a further requirement of the underwriters that the pressure storage capacity be subdivided into several small units rather than concentrated in a single large unit. Compressed air connections to the tanks from a compressor in the power plant of the sub-basement permit keeping the desired air space in them, a pressure of 75 lb. being constantly maintained. All of the tanks, both gravity and pressure, are filled by one of the motor-driven house pumps in the sub-basement. The tanks have 6-in. connections to the pressure main leading to the dead riser, a feature of which connections is the use of check valves in each, which are so placed as to permit free flow into the dead riser but prevent return flow in case of excess pressure in either the pressure or gravity tanks, or in case a fire engine is pumping into the system through the Siamese steamer connection at the sidewalk. There is normally a considerable excess pressure in the pressure tanks that would otherwise cause overflow into the gravity tanks, but this provision is also serviceable in preventing loss of stored water in case of leakage from either set of tanks.

The system of fire protection was designed by the Thompson-Starrett Co., New York, who designed and installed also the mechanical equipment of the building, described in The Engineering Record of Feb. 23, 1907. The entire sprinkler equipment was supplied and installed by the Phœnix Fire Extinguisher Co. The architects of the building were Messrs. Hale & Rogers, and Mr. R. B. Sherburne, New York.



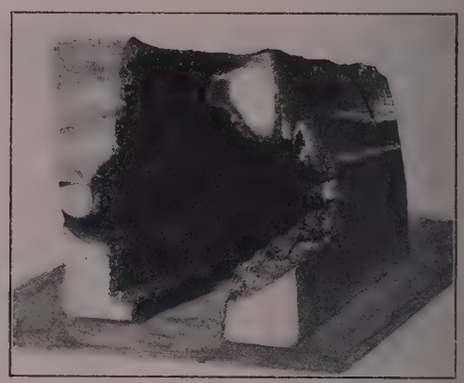
Connection to Concealed Piping.

The German Portland Cement Industry, according to U. S. Consul-General Pitcairn at Hamburg, is looking back upon the year 1906 as an extremely favorable one; the business was more profitable in every respect than during a number of previous years. The joint-stock capital of thirty large works, representing approximately $22,000,000, yielded, roughly estimated, from $2,300,000 to $2,500,000 interest, or 10.7 to 11.4 per cent. In the year 1905 the dividend amounted to about 8.5 per cent., calculated on a capital of $21,200,000. Dividends of the companies in question in the last eight years, 1899-1906, were as follows: 14.3, 11.25, 5.24, 4.41, 5.14, 6.58, 8.5 and 10.7 to 11.4 per cent. respectively. The reason for this favorable development was chiefly the building activity throughout the country in 1906. Although during 1904 and 1905 a similar activity prevailed, prices suffered in those years from the consequences of over-production. Notwithstanding the fact that in 1905 such an over-production did not make itself felt so much as in the preceding year, the production during the year 1906, although a number of new works were put in operation, did not in general exceed in a marked degree the demand. This supposition is confirmed by the statistics of the imports of cement during the last year.

Effect of Fire on Built-Up Beams.

In a letter from Mr. John R. Freeman, in The Engineering Record of Feb. 16, there was an account of the effect of a fire at the Cocheco Mills on double beams. Mr. Freeman has kindly furnished further information concerning this subject, based upon a report by inspectors of the mutual fire insurance companies. The mill was driven by two engines which were belted through the floors of the buildings; the fly-wheels of both engines were inclosed in a wood housing which was without sprinklers and was lighted by incandescent lamps. The belts passed through the brick walls in openings approximately 8 in. wider than the belt and allowing 6 in. clearance above and below it. It seems probable that the fire was caused on account of the breaking of a sprinkler above one of the belt housings; this wet the belt, which consequently slipped and slid sidewise, and came in contact with the housing, so that fire probably ensued. The fire was not put out entirely until abount two days after it had started. This was not only on account of the severe cold which impeded the work of the firemen, but also owing to the difficulty of fighting a fire in a building having double beams.

In this building the floors had double beams with a ¾-in. space between them. They became ignited on the inside and burned continuously in spite of hose streams directed on the bottom or sides, and could not be put out unless water could be thrown directly into the space from below. Beams, therefore, which could not safely be reached, burned slowly for hours until they finally became weakened and broke. This feature materially aided the spread of the fire and partly explains its long duration and exceeding stubbornness.



Section of Burned Double Beam.

The illustration printed above shows clearly a typical example of the beams. Again and again the hose streams were kept on such burning beams from the nearest safe point, in the hope of preventing further fall of floors, but often in spite of this the beams finally let go. The hollow wooden cornices also proved troublesome and fire followed them entirely around until they were consumed and dropped to the ground.

This fire shows there is great danger from belt openings, which quickly carry fire from floor to floor. Brick walls, heavy plank and timber floors do not alone make slow-burning construction; in addition, such floors must be tight, without openings through which fire can quickly pass if for any reason sprinklers do not hold it. The persistence of the fire in the hollow spaces of these built-up wooden beams is a very important lesson to mill architects. The floor beams which fell and complicated the trouble did so as a result of the weakening by the fire that burned inside them where it could not be reached safely by the hose men.

The Mechanical Filters of the Water Works of Harrisburg, Pa.

On Oct. 22, 1905, a mechanical filtration plant was put in service at Harrisburg, Pa., which contains many unusual features. It was run for a couple of months under the direction of the engineers who designed and built it and on Jan. 1, 1906, was turned over to Mr. George G. Kennedy, who has since then been in charge of its management. It has satisfied all the expectations of its designers and the Harrisburg authorities, although the operating conditions are unusually severe. During 1906 it furnished 3,883,794,000 gal. of filtered water, of which 2 per cent. was used in washing the filters. The operating expenses were $5,322.67 for coagulant, $2,122.82 for coal, $276.48 for oil and waste, $971.11 for supplies, $315.84 for repairs, $1,471.38 for laboratory work, and $7,539.10 for labor, a total of $18,019.40. The fixed charges were $10,333.13 for the sinking fund, $10,850 for interest and $1,240 for State taxes. This makes the total cost of the filtered water delivered to the city $10.65 per million gallons.

The works were designed by Mr. James H. Fuertes, consulting engineer of the Harrisburg Board of Public Works, and built under his supervision. He has recently prepared a general description of their leading features and method of operation, which has been made public by the Board of Water and Lighting Commissioners of the city, which is now in control of the plant, and from that report the following notes have been taken.

General View of the Water Purification Plant at Harrisburg.

The filters are located on an island in the middle of the Susquehanna River opposite the center of the city, and are surrounded with dykes about 16 ft. high for protection during floods. The plant comprises, in brief, an intake, a low-lift pumping station, a sedimentation basin, two secondary coagulating basins, twelve rapid filters, a filtered water reservoir, and a conduit leading under the bed of the river from the filtered water reservoir to the high-lift pumping station in the city.

The River Water.—Where it flows past Harrisburg the Susquehanna River is a broad, shallow, rapidly flowing stream draining about 25,000 square miles of hilly country in Pennsylvania and New York.

The watershed is divided into three distinct drainage areas, each of different superficial geological structure. Floods from these valleys carry down detritus characteristic of their peculiar watersheds; those from the Juniata being accompanied with very heavy clay turbidity of a reddish or yellowish color, those from the West Branch carrying silt and silicious particles mixed with more or less clay and mud, while those from the North Branch bring down clay, silt and coal dust in enormous quantities. All three branches are polluted with the sewage of the cities above Harrisburg, having a combined population of considerably over half a million people. During a general flood from all these branches, each stream preserves its characteristic appearance, even after joining, some 20 miles above Harrisburg to form the main river, and as it flows past Harrisburg, the channel on the Harrisburg side will be as black as ink, the central portion will carry the brownish water from the West Branch and the western channel the yellow or red clay waters from the Juniata. On the other hand, a heavy storm on any one branch, to the exclusion of the others, will produce a river having the characteristics of that branch.

Before railroads supplanted canals, numerous dams were built across the Susquehanna and its branches to provide slack water navigation and form feeders for the canals. These dams are practically all in existence to-day and break up the stream into pools from one to five miles long, separated by long stretches of relatively steep rocky river bottom.

One of the complications in connection with the proper purification of the Susquehanna River water at Harrisburg arises from these conditions, and suggested the undertaking of an extended investigation to determine the proper method of preparing the water for final purification, as it was observed the water sometimes contained, in addition to the coal dust, clay and silt, large quantities of flocculent coagulated matter which would clog up a filter to a condition of water tightness in a few minutes. It was also observed that the numbers of bacteria, particularly those of sewer origin, apparently bore a relation to the volume of stream flow opposite to that usually found in normal waters, and at times of very low flow, the water was apparently better in all regards than when a larger volume was flowing in the river.

Preliminary Investigations.—Before undertaking the preparation of plans for the filter plant therefore, the Board of Public Works, adopting the suggestion of Mr. Fuertes, decided to equip an experimental plant and carry on under his direction an extensive series of tests through the season of bad water, so that the actual behavior of various types of filters and preparatory processes could be studied in detail in connection with this particular water, and a process be found that would insure reliability of action combined with simplicity of operation. As a result of the work, the plan finally proving most efficacious and economical for Harrisburg was found to be rapid filtration, using aluminum sulphate as a coagulant, preceded, when the water was turbid, by about 8 hours' subsidence with or without preliminary coagulation, according to the character and amount of turbidity present in the water.

The winter of 1903-4 was occupied in preparing the detailed plans and specifications for the municipal works and bids were received for their construction on April 13, 1904. The contract was awarded to Coder & Miller, of Harrisburg, the terms of their contract binding them to have the plant completed and ready for operation by May 1, 1905. Owing to various delays, however, the filtration of the water was not begun until the latter part of October of that year.

The Intake.—The water is taken up from the river at a point about 250 ft. from the east shore of the island through a concrete-steel intake cage and a line of 42-in. cast-iron pipe terminating in the suction well of the low-lift pumping station at the filter plant. The river being quite shallow and swift a special form of intake cage was designed to meet the existing conditions, and reduce the troubles from anchor ice to a minimum. It is a triangular reinforced concrete structure resting upon the solid rock river bottom, the top and sides being closed and the open side being parallel with the trend of the current. The 42-in. pipe leaves at the apex of the triangle opposite the open side. The opening is 20 ft. long and 18 in. high and screened with 1-in. round wrought-iron vertical bars in two rows, 6 in. apart, the bars in the two rows being staggered and 6 in. apart in the clear.

Power Plant.—The power plant has a 32x45-ft. boiler room with two 6x18-ft. tubular boilers, with Wilkinson stokers, and draft is furnished by a brick chimney about 90 ft. high above the flue connection. The 36x60-ft. engine room has two 16,000,000 gal. main units consisting of Fleming engines direct-connected to Worthington volute pumps, three 12-in. Worthington centrifugal direct connected to Harrisburg engines and used for drainage or pumping wash-water, a Root rotary blower for agitating the sand beds, two Marsh air compressors for agitating the chemical solutions in the mixing tanks, four Worthington solution pumps, an auxiliary pump to furnish pressure water to the hydraulic cylinders of the filter valves in case the city pressure should be shut off, and the customary equipment of auxiliaries for a high-grade steam power plant.

Sedimentation Basin.—The discharge from the main pumps goes through a 30-in. cast-iron pipe to the sedimendation basin which lies on the westerly side of the plant, the dykes forming three of the sides, and the fourth side being finished with a concrete retaining wall above the natural ground level. This basin is 16 ft. deep and holds 4,317,000 gal. when filled to the top. As ordinarily operated it contains 4,000,000 gal. The average width and length at the top are 170 and 282 ft., respectively. In the southeast corner of the basin stand the two secondary coagulating basins, each 33 ft. wide, 45 ft. long, and 16 ft. deep. The basin has concrete covered side-slopes and concrete bottom graded to drain to an outlet connecting with a manhole standing just outside the basin.

Just before reaching the sedimentation basin the 30-in. force main divides, one branch extending full size straight to the north end of the basin and the other, a 24-in. line, going off at right angles and entering the coagulating basins. The branch entering the north end of the sedimentation basin terminates at the slope paving in the northwest corner, a 48-in. reinforced concrete

pipe 2 in. thick, extending from this point clear across the basin at about half depth along the north slope and being supported on concrete brackets 8 ft. apart. This concrete pipe is closed at the west end and has openings 6 in. square at intervals of 4 ft. along the bottom, to insure an even distribution of the water entering the basin. A similar pipe across the south end of the basin, at a slightly higher elevation, but with the holes along a line near the top of the pipe, decants the water and delivers it into the coagulating basins. Both pipes have 2-in. holes at intervals for drainage and the escape of air to prevent rupture or flotation. In the outlet pipe, near the secondary coagulating basins, there is a system of perforated copper pipes for the delivery of the coagulant solution, and a similar set of pipes is placed in the 30-in. force main between the pumps and the sedimentation basin. These will be described more in detail in connection with the coagulating apparatus.

Secondary Coagulating Basins.—The secondary coagulating basins receive the settled water from the settling basin, or from the 24-in. branch of the force-main direct, in a rectangular manhole at the west side of the basins, 4 ft. wide and 6 ft. 8 in. long, containing three large sluice gates, one to close off the supply to both basins and one to admit water to each or either compartment. The entering water, charged with the coagulant, is distributed across the end of each basin through perforations in a concrete flume against the wall at about half depth, and is taken out at the other end through a similar flume and in a similar manner, to a manhole connecting with a 42-in. riveted steel pipe leading to the filters. The coagulating basins hold, together, 334,000 gal., or half an hour's flow when the water consumption is at the rate of 16,000,000 gal. per day; this, when combined with the storage upon the surface of the filters, gives pretty nearly an hour's period of coagulation when the filters are operating at the rate mentioned.

The side walls of the basins are very heavily reinforced with steel bars to resist water pressure from either side, combined with ice-pressure from without, and have concrete roofs 6 in. thick, reinforced with steel bars and supported on beams and posts of the same construction. Each basin is provided with a manhole with steps for entrance, and with valve-controlled drains leading to the sewer. The bottoms of the basins are reinforced and were laid as a monolith.

Filter Plant.—The filter plant proper is a four-story structure, two stories being below ground and two above. The lowest story is the filtered water basin; the second story contains the filters and pipe gallery; the third story contains the coagulant mixing tanks and the operating room where the filters are controlled and the top story contains the coagulant storage room, the office, a general supply room, the laboratory and a lavatory. This portion of the plant adjoins and lies immediately south of the engine room.

Filtered Water Basin.—The filtered water basin is rectangular in plan, 69 ft. wide, 104 ft. 7 in. long at the bottom, and 14 ft. 6 in. deep. Deducting the space taken up by the piers, supporting the filters, etc., the capacity of the basin is about 16,000,000 gal. daily.

Filters.—The filters, of which there are twelve, are arranged in two rows of six each, and are supported on concrete arches resting on transverse arched walls carried by piers resting on the bottom of the reservoir. The transverse arched walls are 3 ft. thick and the vertical piers are 3x4 ft. in section. All the concrete in this heavy mass work is mixed one part Portland cement, three parts sand, and six parts broken stone, and is not reinforced.

Each filter is a box of reinforced concrete 16 ft. wide, 27 ft. long and 9 ft. deep, built independently as a monolith, and has an effective area, at the sand surface, of 0.01 acre. The concrete for the filters was mixed one part Portland cement, two parts sand, and four parts broken stone, and when once started concreting was not allowed to be stopped until the entire filter was completed. Each filter was built in this manner, entirely independent of all others.

At the outer end of each filter a circular manhole 30 in. in diameter was placed to permit placing or removing the sand. The roof of each filter covered it up completely to within 5 ft. 6 in. of the inner face of the box. This space was left open to give access to the filter from the operating floor and permit watching the operations of washing and the degree of coagulation of the applied water.

Valves.—Each filter is controlled by six valves located in the pipe gallery; one to admit raw water upon the surface of the filter, one to control the rate of filtration, one to control the admission of wash water, one to control the admission of compressed air, one to control the escape of the dirty wash water and one to control a drain for emptying the filter. Each of these valves is provided with a hydraulic cylinder for opening and closing, operated by water pressure from the pressure main.

Pipe Gallery.—Between the two rows of filters, which stand 15 ft. apart from face to face, and carried on concrete steel beams extending across the space from pier to pier, is the pipe gallery, in which are located all the pipes and valves connected with the filters. This gallery is water tight and when the plant is in operation, its floor is about 3 feet below the level of the water in the filtered water reservoir and subjected to an upward pressure equivalent to this height.

Underdrains.—Each filter contains a system of pipes near the bottom for the removal of the filtered water, and for distributing the wash water and compressed air during the operations of washing, a 7-in. bed of gravel of assorted sizes surrounding these pipes, a bed of specially prepared sand 30 in. deep, resting upon the layers of gravel, and two steel troughs reaching across the filter longitudinally to admit the unfiltered water upon the filter and remove the dirty water when the filter is being washed.

The underdrainage system of each filter is in two equal sections; the effluent from each section discharging into the main effluent pipe which passes below the bottom of the filter into the effluent controller in the pipe gallery. Each section consists of a central cast-iron manifold built into the concrete floor of the filter, and a series of parallel horizontal pipes with perforations on their lower sides. From the manifold 1¼-in. pipes rise vertically 6 in. apart, connecting into 1¼-in. galvanized iron T's, from the horizontal runs of which 1¼-in. galvanized iron pipes extend either way nearly to the sides of the filter. These pipes are capped at their free ends, and have 7/32-in. holes drilled along the bottoms of each 3 in. apart from center to center. The bottoms of these pipes lie all in the same horizontal plane and 1 in. above the floor of the filter. No special screens or strainer cups are used to prevent the sand from working down and passing out with the filtered water, and no specially constructed orifice boxes for the admission of compressed air during washing. The gravel underdrains consist of two layers of gravel, the first composed of stones passing a ¾-in. and remaining upon a ¼-in. screen; this layer is 4 in. thick. The top layer is 3 in. thick, and made up of gravel passing a ¼-in. mesh screen, but remaining on one having 12 meshes to the inch, with not over 2 per cent. that will pass a sieve having 15 meshes to the inch. These sizes were determined practically for the particular gravel to be had locally; with different materials possibly other grading might prove more advantageous.

Sand.—The filter sand was, with the exception of a small amount, secured locally from the Susquehanna and Juniata sand bars, and was prepared in the filters by alternate washings and scrapings to remove the fine materials carried to the surface. The specifications called for sand not more than

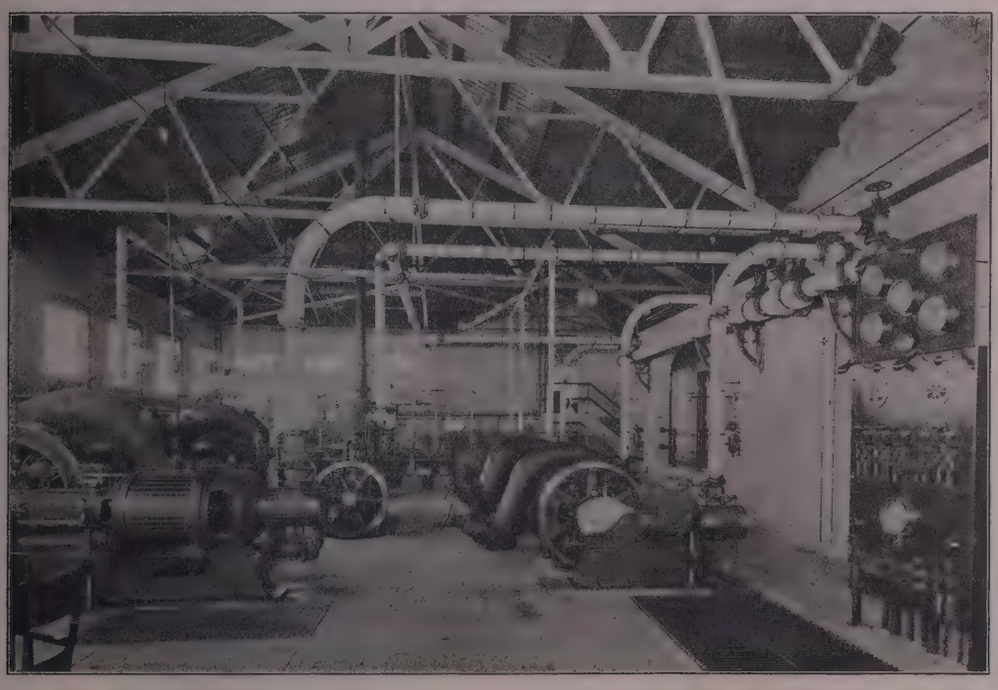
View In Operating Room.

Apparatus for Control of Solutions.

¼ per cent. of which should be smaller than 0.24 mm.; not more than 10 per cent. smaller than 0.35 mm.; at least 90 per cent. finer than 0.80 mm.; practically all particles smaller than 1.00 mm.; and the uniformity coefficient from 1.3 to 1.4. The Susquehanna River sand was known from analyses to be satisfactory as to chemical composition and no restrictions were placed on it in this regard, although if an imported sand were used, the specifications stipulated the limiting amounts of lime, magnesia, iron, and alumina permissible.

The sand was finally prepared, conformed to these specifications, the average effective size being about 0.38 mm., and the average uniformity coefficient 1.3.

Raw Water Main and Shutter Valve.—The raw water main bringing the coagulated water from the secondary coagulating basin enters the pipe gallery from the south end and passes through the center of the gallery on special concrete piers at a height of 7.38 ft. from the floor of the gallery to the center of the pipe. The pipe is 42 in. in diameter past the offtakes for the first three pairs of filters, reducing to 36 in. for the remainder of the distance. The free end is closed with a cast-iron cap. Just after entering the pipe gallery a 42-in. shutter valve, especially designed for this work, is placed in the 42-in. pipe. This valve is opened and closed by a hydraulic cylinder operated by a float resting on the water in a small concrete chamber connected by means of a pipe with the 42-in. main about midway of its length. The object of this valve is to automatically maintain the water on the filter at a constant depth. Vent pipes, 2 in. diameter, out of the top of the raw water main and discharging over the filters, afford relief from water hammer. Opposite each pair of filters 12-in. branches leave the raw water main, dividing into two lines leading to the two raw water inlet troughs to each filter. From the point where these two branches separate a third branch drops downward and connects with the central sewer on the floor of the pipe gallery. This sewer takes the dirty wash water to the drainage chamber under the engine room or to the 24-in. cast-iron sewer according to the stage of the river.



View in Engine Room of Low-Lift Pumping Station.

Control of Valves.—All the valves are manipulated from the operating room above the pipe gallery. Each hydraulic cylinder has two small pipes leading, one from either end of the cylinder, to a four-way cock in a manifold underneath the operating table from which it is controlled. These four-way cocks have four pipe connections each, one from the pressure main, one to each end of the hydraulic cylinder and one for a waste pipe. By turning the valve in the proper direction, therefore, water from the pressure-main passes to the corresponding end of the hydraulic cylinder, raising the piston and opening the valve, the water from the other end of the cylinder being forced out through the upper pipe to the four-way cock and thence to the drain. A reversal of the direction of opening the four-way cock closes the valve. The spindles of the four-way cocks are carried up by rods through the operating tables and terminate in nickel-plated brass handles. To the piston of each cylinder a phosphor-bronze wire leads over pulleys to a grooved wheel lying horizontally below the top of the proper operating table and just back of the handle for operating that particular valve, the axle of the grooved wheel being carried up through the top and carrying a pointer which shows the extent to which the valve is opened or closed.

Effluent Controller.—Each 14-in. effluent valve, in addition to being controllable by hand, in this way, has an automatic device by means of which the rate of filtration is regulated. Through this 14-in. valve the filtered water is discharged into a concrete box 3 ft. 6 in. wide, 5 ft. long, and 2 ft. 6 in. deep, built on the floor of the pipe gallery close to the front of the filter. In the bottom of the box is a bronze plate having an orifice 6 in. wide and 10 in. long, a hole somewhat larger than this being made through the concrete floor to allow the filtered water to fall through the orifice to the reservoir underneath. This bronze orifice plate is provided with a slide operated by a screw and worm-gear from the operating table above, to allow of changing the size of the orifice at will. A pointer traveling along a scale on the operating table indicates the extent to which the orifice is opened and also the quantity of water in gallons per 24 hours passing through the orifice when the water in the box stands 2 ft. deep over the orifice plate. By maintaining the water at this depth in the box, therefore, a constant rate of discharge is secured, and this rate can be changed to suit the necessities of the case by opening and closing the slide.

The water is kept at a constant depth by means of a float resting on the water in the orifice box. This float carries a vertical-toothed rack, engaged in a toothed wheel fastened to a spindle of a small four-way cock piped to the hydraulic cylinder on the 14-in. valve. The rise or fall of the water in the orifice box will therefore partially close or open the 14-in. valve, and in a short time come to rest at the proper place to maintain a constant level in the box. As the filter clogs up the 14-in. valve is gradually and slowly opened to correspond, so that the rate of filtration is maintained at a uniform speed automatically.

At times when the filters are delivering more water than the pumps are taking away, the water in the filtered water reservoir will rise up and submerge the orifice plates thus reducing the head over the orifice and cutting down the discharge in accordance with the degree of submergence. If the Harrisburg pumps should be shut down, therefore, the filter plant would also automatically stop filtering water without accident or inconvenience. As the plant is run the greater part of the time with the orifices submerged, a differential gauge was designed to show automatically the percentage of the full-rated discharge for different depths of submergence. This gauge stands on the operating table, and is controlled by two floats, one resting on the water in the filtered water basin, and the other on the water in the orifice box. These two floats, by means of phosphor bronze wires, operate an index pen, tracing a line on a paper disc rotating on its axis once in 24 hours, and divided into hours, radially, and concentrically into percentages, from 0 to 100 per cent. The disc is operated by clockwork. Thus, if the filter is set to deliver 1,000,000 gal. daily with a free discharge through the orifice but the orifice runs submerged, the actual discharge is obtained by multiplying the free discharge by the percentage shown on the disc.

There is also placed on each operating stand a loss of head gauge showing by means of a pointer and revolving disc, each operated by a float, one on the filter surface and the other on the water from the underdrains, the loss of head, an indication of the amount of clogging in the filter while in operation. These are arranged by means of an electrical connection to ring a gong when the loss of head reaches about 9 ft., as it is then necessary to wash the filter and start it over afresh. On the top of each stand a pearl push button gives the signals to the men in the engine room when filters are ready for washing. Each filter has its own operating stand, which is located in front of it on the operating floor.

Operating Room.—The operating room containing these tables is 28 ft. wide, 106 ft. long and the ceiling is 10 ft. 9 in. above the floor. The operating floor is 15 ft. wide, of reinforced concrete, carried by reinforced beams spanning the pipe gallery, with openings at each operating stand provided with ladders for descending to the pipe gallery floor.

Coagulant Storage Room.—The 28 x 53-ft. coagulant storage room is over the north end of the operating room and is designed for a load of 750 lb. per square foot. There is storage space for about 200 tons of chemicals. In this room are scales for weighing out the chemicals, a coagulant hoist for raising the barrels to the room from the ground outside, and the coagulant regulating orifice boxes.

Chemical Mixing Tanks.—The tanks for mixing the chemical solutions are located to the west of the operating room and rest on the tops of the three north filters of the west row. There are four of these tanks, two are 11 ft. wide, 16 ft. 9 in. long, and 7 ft. 6 in. deep, inside, for mixing the coagulant solution, and two, 11 ft. wide, 8 ft. long, and 7 ft. 6 in. deep, for mixing the soda ash solution. These tanks are of reinforced con-

crete. The brick wall of the building is carried around the tanks on the south, west and north sides, and they are covered over with a sloping, hipped roof carried on steel roof trusses, and provided with large skylights of wire-glass. Each coagulant tank contains, in one corner, at the top, a cage with a copper wire bottom, supported on reinforced concrete beams, in which the crystals of aluminum sulphate are placed after weighing.

The crystals are dissolved by a spray of water from a perforated pipe. By the time the tanks are filled the chemicals are dissolved. To maintain the solution of uniform density they are kept in agitation by compressed air forced in through a system of perforated copper pipes at the bottom of the tanks, the air being supplied by the Marsh air-compressors in the engine room. The arrangement for the soda mixing tanks is similar except that the air pipes are of galvanized iron instead of copper.

From these mixing tanks the solutions go by gravity through copper pipes to the coagulant pumps, and through galvanized iron pipes to the soda pumps, in the engine room, which force the solutions up to one or several of the six orifice boxes in the coagulant storage room.

Coagulant Orifice Boxes.—The orifice boxes measure and control the amount of solution used and are regulated to give the dosing required by the water under different conditions. Two of the orifice boxes are for soda and four for coagulant solution. Two of the coagulant and one of the soda boxes are designed for hand regulation and two coagulant and one soda for automatic control.

These boxes are arranged in a nest and are each 2 ft. wide, 3 ft. long and 27 in. deep over the orifice plates. They are placed above three other boxes 15 in. wide, 4 ft. 6 in. long and 20 in. deep, from which the solutions are conducted to the points of application, and which serve also as measuring boxes to occasionally check up the discharge of the orifices.

In the bottom of each orifice is a rectangular slot over an opening through the bottom of the box. In this rectangular slot, which is 3½ in. long and ½ in. wide for the coagulant and ¼ in. wide for the soda solution boxes, fits a slide of corresponding width which can be moved in or out, to change the size of the orifice, by means of a bronze screw, having 10 threads to the inch, on a spindle passing through a stuffing box on the front of the orifice box. The spindle carries a nickel-plated brass wheel 6 in. diameter, the face of which is graduated into a hundred divisions; and standing at right angles to the face of the box, in a position such that the rim of the wheel will just clear it, is a scale divided from 0 to 4 in., by tenths of an inch, adjusted so that when the slide of the orifice is tight shut, and the opening completely closed, the rim of the wheel will be at the zero mark on the scale. The amount the orifice is to be opened is determined by the strength of the solution used, by the quantity of water being filtered, by the depth at which the solution stands over the orifice box and by the amount of chemical required per gallon of water filtered.

When the filters are running with free discharge from the effluent orifice boxes the solution is maintained at a depth of 2 ft. in the solution orifice boxes by float-and-lever valves placed on the discharge pipes from the solution pumps. A connection between these discharge pipes and the Foster pump-governing valves automatically regulates the pumps, by throttling the steam supply, to a speed sufficient to furnish the required quantity of solution without excessive pressure at the pumps, or against the float-valves. Two of the coagulant and one of the soda solution boxes are arranged thus, the quantity of solution used being regulated by hand.

Automatic Regulation of Coagulant and Soda Solution.—The three other boxes have an automatic apparatus whereby, when once the proper dosing has been regulated by hand, the quantity supplied will be governed by the quantity of water filtered. This is quite an essential part of the plant when the filter effluent orifices are submerged by the raising of the water in the filtered water reservoir. At such times the filters will be delivering less water than the quantity for which they are set when running under free discharge, and unless the quantity of chemical solutions were reduced, too much solution would be admitted for the quantity of water actually being filtered.

This regulation is accomplished by automatically reducing the depth of water over the orifices in the solution boxes in the same amount that the filter orifices are submerged. When the filter effluent orifices are submerged to depth of 2 ft., the filters are automatically shut off, and no water is being filtered.

At such times, therefore, no solution should be used. The device for accomplishing this regulation consists of a large float in the filtered water reservoir placed so that it travels vertically up and down with the water in the reservoir when it rises above the level of the filter effluent orifice plates.

To this float phosphor bronze wires are attached, and carried up, over guiding sheaves, to the top of the three solution boxes, where they are attached to three bronze carriages traveling vertically on guides in each of the boxes. On each carriage is fastened a float and lever valve, and connection is made between the valve and the solution pump discharge pipes at the tops of the tanks by means of soft rubber tubing. When the water in the filtered water reservoir rises above the filter effluent orifices, therefore, the large float rises and the carriages carrying the float and lever valves, in the three solution boxes, are lowered an equal amount, decreasing the depth of water over the solution orifices correspondingly and hence reducing the quantity of solution pouring through the orifices to correspond with the reduction in quantity of water being filtered.

Gauges.—On the face of each orifice box is placed a glass tube gauge with graduated scale adjusted so that the zero point is at the level of the orifice plate. This shows at all times the depth of solution over the orifices. There are, in addition, three self-recording depth gauges, one for each pair of coagulant solution, and one for the two soda solution boxes. These are operated by floats in standpipes connected with the bottoms of the boxes, the connections being provided with valves to cut out, or to cut in, either box of the pair.

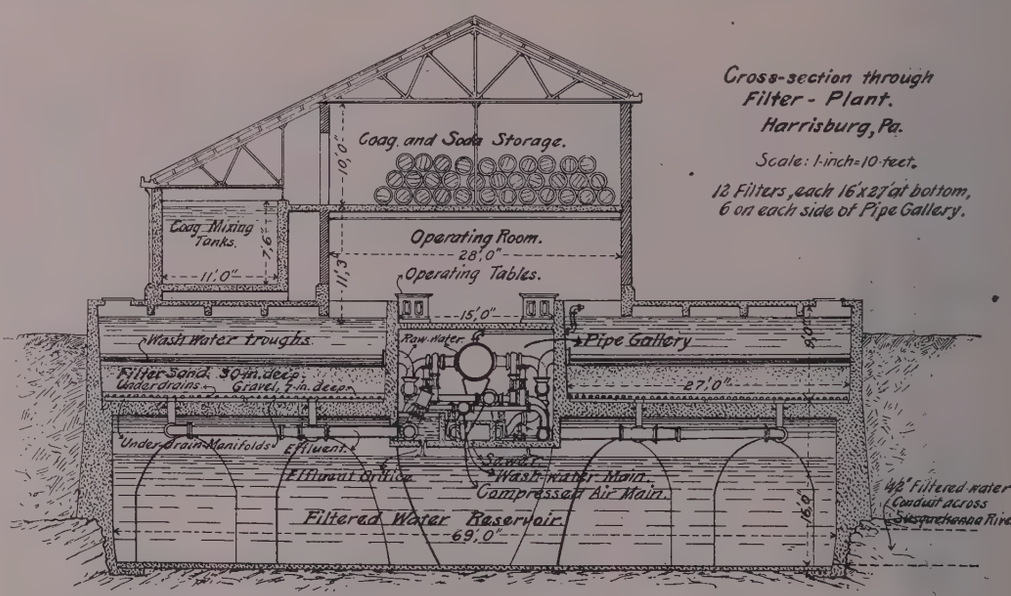
Self-recording gauges rest on the top of the standpipes. Each gauge has a clockwork movement rotating a dial on which a pen, operated by the float, makes a trace showing continuously the depth of the solution. The removable paper dials are graduated radially into 24 hours and concentrically into feet and tenths. By these dials the exact quantity of solution used can be determined for all conditions of operation. In actual use they have shown their utility and justified their existence. If anything goes irregularly with the filters the gauge records tell the tale and give the time the trouble occurred, thus making it possible to place the blame, if any, on the man in charge at that time.

Application of Coagulant Solution.—The solutions fall from the orifices into the boxes below, from which the pipes conveying the coagulant to the raw water lead to the different points of application. All the pipes in connection with the coagulant solution are of copper with acid bronze valves and specials. All the pipes for conveying the soda solution are of galvanized iron with bronze valves. The soda solution is introduced into the raw water at the entrance to the intake well before the water passes through the low-lift pumps.

A manifold of perforated pipes is placed in the intake well and hung on a swivel joint on a horizontal axis at the top. The soda solution pipe connects with the manifold through this axis. The manifold was hung in this way to permit ice and other floating matters that might be brought in with the water to pass without forming a dam behind the manifold.

The coagulant solution can be admitted at two points, as necessary. One connection is in the 30-in. force main between the pump connections and the sedimentation basin; the other is in the 48-in. reinforced concrete pipe at the south end of the sedimentation basin just before the water enters the secondary coagulating basins. Both connections are through manifolds of perforated copper pipes. The manifold in the 30-in. pipe is in two halves hung on horizontal axes, the manifolds standing at an angle of 45 deg. with the horizontal against the direction of the current, so as not to form obstructions to cause the arrest of such matters as might go through the pipe with the raw water.

In the operation of the plant, the coagulant, when the water is in good condition, is admitted



Cross-Section Showing General Arrangement of Harrisburg Filters.

only through the connection at the entrance to the secondary coagulating basins; when bad it is admitted through both connections. Various combinations are used, depending on conditions.

Coagulant Hoist.—The coagulant hoist consists of a hydraulic cylinder operated by water pressure, the piston of the cylinder carrying sheaves over which a rope passes to a set of blocks and thence to a carriage, running on overhead tracks, and arranged so that the barrels of coagulant are raised vertically, until above the floor of the coagulant storage room, at which point a dog

View in Pipe Gallery Showing Apparatus for Effluent Control.

is automatically thrown out which allows the carriage to roll in on the tracks to such place as is desired to deposit the barrel.

Office and Laboratory.—Adjoining, and just south of the coagulant storage room is the office of the superintendent, 15 ft. x 19 ft. 10 in., next to which is the storage room 11 ft. x 19 ft. 10 in. The southern end of this floor is occupied by the chemical and bacteriological laboratory. This is one of the most complete, finely finished and equipped laboratories for water analysis in the country. The apparatus is that which was purchased for use in the laboratory of the experiment station built before the plans for the municipal plant were commenced.

Filtered Water Mains.—The filtered water, as previously explained, falls through the orifice plates, in the effluent orifice boxes, to the filtered water reservoir beneath the filters. This reservoir provides a reserve of water sufficient to balance the irregularities in draft due to washing filters, starting pumps, etc. The main storage to balance the irregularities of draft by the water consumers is located on a hill to the east of the city and holds about 20,000,000 gal. From the filtered water reservoir a 42-in. cast-iron pipe is laid in a trench across the bed of the Susquehanna river to deliver the water into the pump-well of the high-lift pumping station of the city's water works.

Capacity of the Plant.—Each main pump and engine in the low-lift pumping station at the filter plant can, under the maximum conditions, economically discharge about 16,000,000 gal. of water per day into the subsiding basin. Space is left in the engine room for the installation of a third pump and engine. After this third pump is installed the capacity of the low-lift pumping station will be 32,000,000 gal. daily with one pump and engine in reserve. The twelve filters, operating at a rate of 100,000,000 gal. per acre per day, will deliver 12,000,000 gal. gross, daily. It was found at the experiment station, that, as far as efficiency was concerned, the filters, when the water was properly prepared for filtration, would do as well at a rate of 166 2/3 million gallons per acre per day as at lower rates. At that rate the gross capacity of the plant would be 20,000,000 gal. daily, from which should be deducted the wash water and reduction of output due to the filters out of service during washing, which, for average conditions, would make the net yield of filtered water a little less than 19,000,000 gal. daily. The water consumption in the city is now from ten to eleven million gallons per day.

The total expenditures in connection with the works were $22,242.25 for the preliminary investigation, $3,855.47 for land, $11,820.69 for the intake, $35,043.95 for grading and dykes, $51,437.42 for the pumping station, $21,485.66 for the sedimentation basin, $11,579.33 for the secondary coagulation basin, $80,527.01 for the filter plant, $15,953.17 for the filtered water reservoir, and 63,526.64 for the pipes across the river.

Reinforced Concrete has been adopted for lighthouses and for the dwellings of the light keepers in the Philippines.

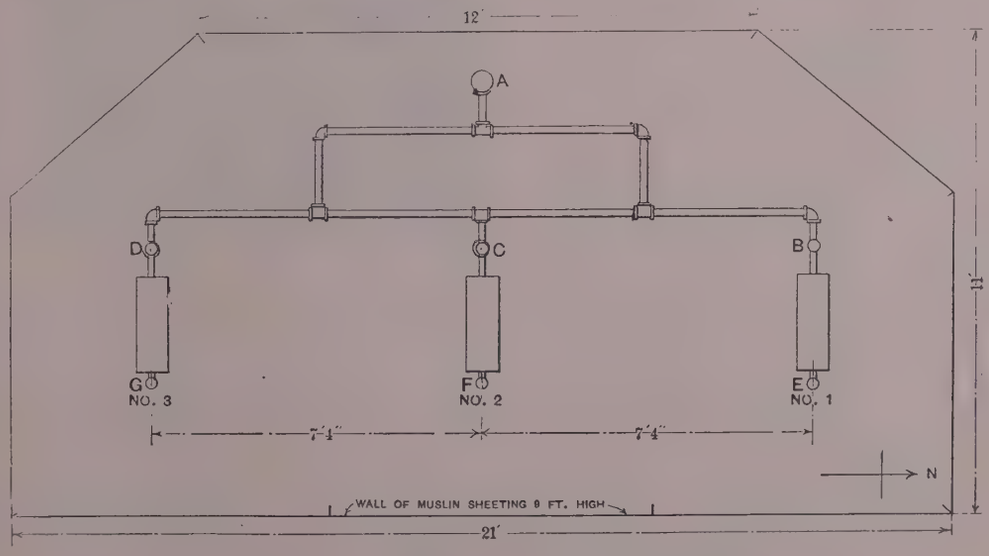
Tests of Direct Radiators.

At the last convention of the American Society of Heating and Ventilating Engineers, the Committee on Tests presented a report on a series of experiments recently made with direct steam radiation, which presents valuable data regarding the heat radiated per degree of difference of temperature per square foot of surface per hour in standard cast-iron radiators. The committee consisted of Prof. James D. Hoffman, chairman, and Messrs. William G. Snow, H. A. Loeb, S. G. Neiler and C. R. Bradbury.

The following outline, covering a series of tests on radiators to determine their relative heating capacity, was given to your committee to be embodied as a part of the report. It is, therefore, included as an illustration of the method employed in the work. The radiators were of different makes, each containing ten 38-in. sections, and the test was for the purpose of determining the comparative value of the radiators as heat transmitters.. In determining the extent of outside surface one inside and one outside section were dealt with for each radiator. Each section thus dealt with was divided by fine lines into elementary areas, and pieces of thin linen paper were cut and fitted to cover each section. The areas of the pieces thus cut were determined by planimeter for the total area of the section.

The arrangement of the testing floor is shown in the accompanying drawing. The three radiators to be tested were mounted in line at a distance of 7 ft. 4 in. apart. They were supplied with steam by a single pipe delivering at the point A, from which point pipes of equal length led to the several radiators. At A. B. C and D separators were placed to catch the entrained water; the presence of these insured a supply of dry steam for each radiator. The condensation from each radiator was caught in a covered chamber (E, F and G) with glass gauge attached. A pressure gauge was attached to the supply piping near A. The temperature of the air was obtained by means of a separate thermometer suspended below each radiator (H, I). To screen each radiator from accidental air currents a 9-ft. wall of cotton muslin was set up from the floor several inches to permit a circulation of air to the radiators from below. No horizontal air currents, however, could be detected near the radiators by the most sensitive anemometer.

In preparation for the test steam was admitted to the radiators at a pressure of 5 lb. gauge, and the condensation was drained off at such a rate as to maintain a constant level in the water



Plan of the Radiator Testing Arrangements.

glasses. This level was sufficiently low that it insured the radiators being drained at all times. The air cocks were opened a slight amount to insure the discharge of any air which might enter the radiator. After one or two hours of preliminary heating, and when all conditions had been made constant, record observations were taken. A bucket containing a sufficient amount of cold water to make the total weight 6 lb. was had in readiness for each radiator. The outlet valves for each radiator were manipulated until the water levels were at a fixed height, after which, upon signal, the buckets were placed in position to receive the drainage.

OBSERVED RESULTS OF RADIATOR TESTS.

Date.	Radiator A. Condensate per hour.	Radiator A. Position of radiator.	Radiator A. Temperature.	Radiator B. Condensate per hour.	Radiator B. Position of radiator.	Radiator B. Temperature.	Radiator C. Condensate per hour.	Radiator C. Position of radiator.	Radiator C. Temperature.
Apr. 17.	12.375	3	72	11.875	1	70.2	12.688	2	70.2
Apr. 18.	12.063	1	69.8	11.688	2	69.6	12,750	3	71.2
Apr. 19.	11.220	2	78.4	11.125	3	78.6	11.688	1	78.6
Aver.	11.886		73.4	11.563		72.8	12,375		73.3

Observations of pressure and temperature were taken every 15 min. and the test was continued for 1 hr., after which the buckets were simultaneously moved and weighed, the difference between the initial and final weights giving the condensation for the test and forming the basis from which to determine the amount of heat radiated from each of the several radiators.

To insure that each radiator would get the benefit of the same exposure, providing any difference did exist due to its location, the test was carried through three times, the position of the radiators being interchanged each time. Thus, if the positions of the radiators were numbered 1, 2 and 3, each radiator in turn occupied each one of these positions. The observed data as taken from each radiator are given in the table.

From the table the following points of general interest may be taken:

Name of radiator	A.	B.	C.
Weight in pounds	362	345.5	318.5
Actual superficial area, sq. ft.	52.49	50.69	50.10
Gauge pressure during test, lb.	5	5	5
Temperature of surrounding air, degrees F.	73.4	72.8	73.3
Difference in temperature between air and steam	153.6	154.2	154.7
Condensation per hour, pounds.	11.886	11.563	12.375
Heat (B.t.u.) radiated per degree difference of temp. per sq. ft. of surface per hour.	1.41	1.41	1.53

The foregoing calculations refer to exterior surface of the radiator only, as no attempt was made to determine the extent of interior surface exposed to the steam.

An Electric Railway System recently built by the Midland Railway Co. affords an interesting proof that in England as well as in New England the steam roads find it desirable to control some of the electric lines. This system of light railways connects Burton-upon-Trent with Swadlincote and Ashby-de-la-Zouch and Gresley with Swadlincote. The total length of line is 10.2 miles. The cost of equipment, construction and power station was about £100,000, but this figure does not include the cost of land. The system is direct throughout. The point of interest lies in the fact that for driving the generators two Diesel oil engines have been installed, and this is spite of the fact that the power station is built on the top of a coal mine with shaft only a few yards away. The petroleum residue used as fuel costs 54s. 6d. per ton delivered. The guaranteed fuel consumption of each engine at full load is 0.45 lb. per b.m.p.-hour, equal to a cost of about 0.2d. per electrical unit generated. During the first 2 months' running it has been found that the total power expenses were about ½d. per unit. This system is unlike most American roads as regards power plant and is correspondingly interesting.

Hydraulic Sewage Ejector on Lake Ave. South, Duluth, Minn.

By E. A. Wilson, Assistant City Engineer.

In 1904 the Engineering Department of this city was called upon to design a system of sewers for the district known as Minnesota Point or Park Point, a low-lying strip of land 7 miles in length, with an average width of about 400 ft. and about 7 ft. above the normal water level of Lake Superior, extending across the upper end of the lake and forming a natural breakwater to the Duluth-Superior Harbor. This strip of land has been used in the past as a summer resort, but since the construction of the Aerial Bridge, facilitating the transfer of passengers and provisions across the ship canal, it is rapidly being settled by permanent residents. The laying of water and gas mains along this strip of land makes the construction of a sewer system still more urgent, but owing to unfortunate delays in the laying of the water mains across the ship canal, no construction of the proposed sewer system has been commenced.

The problem of disposal of the sewage from this district led to the designing of an apparatus whereby the city water could be used in elevating the sewage at the numerous points necessitated by the low level of the district and its disproportionate length, compared with ordinary conditions. The sewage had to be conveyed to one outlet if possible, in order to keep the sandy beach of Lake Superior on one side and the shore of the bay and harbor on the other side (used for bathing houses, etc.), free from contamination by sewage. The ordinary systems in use for the lifting of sewage would not fit the conditions, or would be too expensive in first cost and operation, considering the comparatively small territory to be assessed.

Sewage Ejector in Place.

A working model was made of an apparatus actuated by water pressure which seemed to solve the problem, both as to first cost and operating expenses. As there was no immediate need of a sewer system on Park Point before the water mains were completed across the canal, the City Council, upon recommendation by Thos. F. McGilvray, city engineer, and personal inspection of the working model, authorized the construction of an ejector on Lake avenue, south, on the city side of the ship canal and the Duluth end of Minnesota Point.

The object of this installation was to relieve the sewer in the avenue from back-water, and if possible eliminate the odor from the rotting sewage. The sewer is a combined one, 2,300 ft. in length, composed of 15, 18 and 20-in. pipes, on a grade of 0.137 per cent. The back-water often filled three-quarters of the entire length of the sewer, its outfall being directly into the ship canal and subject to great fluctuations of the water in the lake. This completely destroyed the small velocity due to the grade and made a septic tank of the sewer, with vents for the obnoxious gases at every catch-basin.

By the introduction of a bulkhead in a manhole, the lake water was shut off and the inlet pipe to the ejector connected with the sewer on the upper side of the bulkhead.

The chamber containing the ejector is built on the side of the main sewer, the course of the sewage describing a semi-circle through the inlet to the ejector, which raises the sewage 3 ft. and discharges it through the outlet pipe into the main sewer again back of the bulkhead, whence its only escape is into the canal.

The ejector chamber is built of concrete, the lower part being built around a steel tank of a height calculated to prevent the ground water from seeping through, its head being ordinarily about 6 ft. through coarse gravel and near the lake. The chamber is elliptical in form, 11 ft. in length by 7 ft. 6 in. in width and 12 ft. deep.

The part of the inlet pipe belonging to the ejector consists of a curved pipe provided with a float chamber, a check valve and clean-outs. A gate valve is provided for, so as to shut off the inflow of sewage if necessary during repairs to the apparatus. The bottom part of the ejector, which is a spherical segment, contains provisions for connecting the inlet and outlet pipes to the apparatus. The sewage receiver, which is bolted to the bottom section, is a bored cylinder 48 in. in diameter. The outlet pipe is provided with a check valve, for obvious reasons. The upper flanged end of the sewage receiver has a ribbed cover to which is bolted an 8-in. bored cylinder. The two cylinders are provided with pistons and rod arranged tandem, the small piston acted upon by the direct water pressure from the mains overcoming the resistance of the sewage against the larger piston. The large piston is provided with a manhole for the inspection of the interior of the cylinder. It is counter-weighted to overcome the friction in the apparatus plus a certain percentage of the weight of the pistons themselves. The small piston is packed with a rubber canvas packing; the sewage piston with hemp packing.

The water from the mains is admitted to the power cylinder through two small piston valves. These valves are worked automatically. During the filling of the sewage receiver the water is completely shut off. When the sewage has lifted the piston to the upper end of the stroke, a head is created under the float in the inlet pipe. This raises a lever which is connected by means of a rod to the small controlling valve and reverses it. This admits about two spoonfuls of water under city pressure, which reverses the large piston valve and admits water to the power piston, which in descending moves the large piston before it and ejects the contents of the receiver.

At the end of the stroke a rod, provided with a set collar at the upper end and secured to the large piston, engages the lever and reverses the valves, at the same time opening the exhaust ports, from both the valves and the power cylinder, and shutting off the water supply. The water in the power cylinder is now forced into the sewer outlet by the rising sewage piston as fast as the new charge is received. The apparatus is made of cast iron with the exception of the small valves, which are brass. These valves are leather-packed.

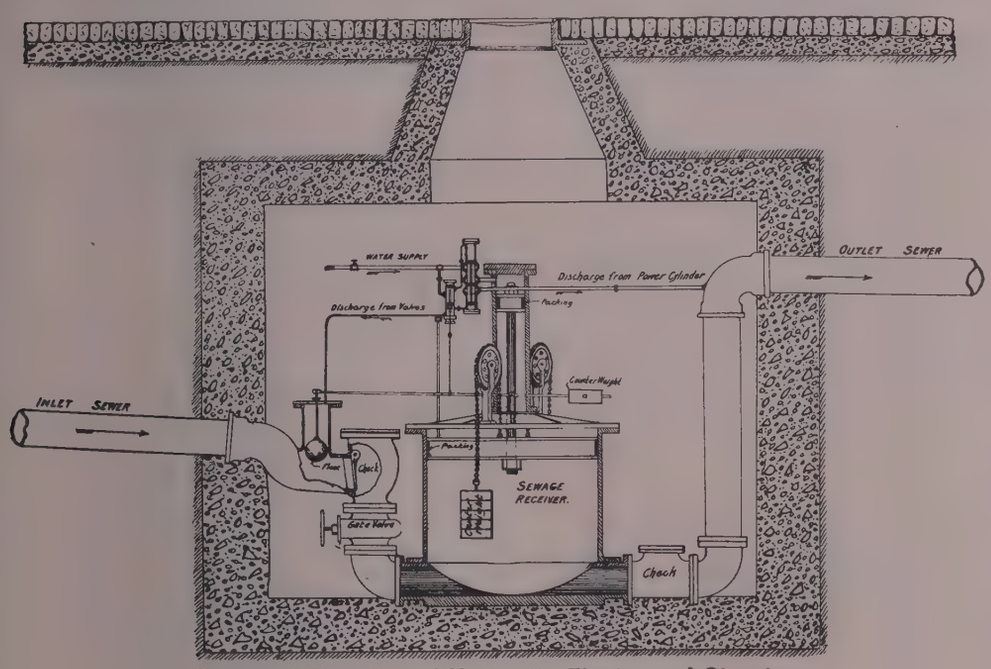
The apparatus was put in operation on Nov. 7 last and has been in continuous operation ever since. Considerable apprehension was felt by some, as to its success in the winter time in this rigorous climate. We have had a long period of cold weather, the thermometer hugging the 30° F.

mark quite frequently, but nothing has happened. The sewer commissioner has given it some attention, from five to ten days between each inspection. Nothing has been done to the packings of the pistons, which appear to be in as good condition as the day they were put in.

The installation of these machines (far below the cost of any other method in use) and the low operating expense entitles them, I believe, to receive serious attention from engineers who have similar problems to deal with.

The total operating expense from Nov. 7 to Feb. 23, when the writer took the last reading of the meter, covering a period of 108 days, was $14.01. The highest observed occurred during a rainstorm in November, when it ran to 56 cents for 24 hours, elevating 648,000 gal. of sewage and storm water. The lowest expense observed was on Dec. 19 and 20, when three consecutive readings showed an expense of 2½ cents per 24 hours.

The apparatus is an excellent sewage meter and an absolute back-water trap. Small apparatus of the same construction can be installed for low basements at moderate cost, and its efficiency, reliability and cheapness in cost of operation has been satisfactorily demonstrated so far by the installation in the Lake avenue sewer.



Sectional Elevation of Hydraulic Ejector and Chamber.

The accompanying table is based on the amount of sewage contributed by a population of 100,000 people, at 60 gal. per capita per day, lifted 4 feet. The cost of operation is based on City of Duluth meter rates of 2 cents per hundred. The table allows for friction in the apparatus.

TABLE OF EFFICIENCY OF HYDRAULIC EJECTOR UNDER DIFFERENT WATER PRESSURES.

Water pres. per sq. in.	Water used.	Volume per day.	Cost per day.	Cost per capita per annum.
25 lbs.	12.12 %	9,696 cu. ft.	$1.94	$0.07
30 "	10.14 "	8,112 " "	1.62	0.06
40 "	7.58 "	6,064 " "	1.22	0.05
50 "	6.06 "	4,848 " "	0.97	0.04
60 "	5.07 "	4,056 " "	0.81	0.03
70 "	4.34 "	3,472 " "	0.69	0.025
80 "	3.79 "	3,032 " "	0.61	0.023
90 "	3.37 "	2,696 " "	0.54	0.02
100 "	3.04 "	2,432 " "	0.49	0.018

THE LOWEST POINT in the United States is the Death Valley in California, where a line of spirit levels recently run by the U. S. Geological Survey indicates that there is a depression about 276 ft. below the sea level. The highest point in the country is Mt. Whitney, rising 14,501 ft. above the sea, which is only 75 miles from the Death Valley. Before the formation of the Salton Sea, there was a point, now submerged by that lake, where dry land was found 287 ft. below the sea level.

The Cost of a 66-In. Reinforced-Concrete Sewer.

The Fassnacht Ave. sewer in South Bend, Ind., is the outlet trunk connection of a combined system furnishing drainage to a flat and marshy area of about 800 acres in the western part of the city. This sewer has a total length of 5,887 ft., and is built of reinforced concrete. The first 1,670 ft. of it is 72 in. in diameter and the remainder 66 in. in diameter. The design and construction of this sewer were quite fully described in The Engineering Record for June 16, 1906. At the recent meeting of the Indiana Engineering Society, Mr. M. L. Morris, assistant city engineer of South Bend presented a paper giving some additional notes regarding the method of construction and the detailed cost of the 2,444 ft. of 66-in. section that was built in 1906, from which the following notes have been prepared.

The sewer section consists of a 9-in. ring of concrete, the arch of which is of 1:2:4 concrete and the remainder of 1:3:6 Portland cement concrete, both made of Portland cement, sand and gravel. The invert was coated up to the springing line of the arch with ½ in. of 1:2 mortar. The outside of the barrel was made vertical to the springing line of the arch, about 18 in. above the bottom of the concrete, for convenience of construction as well as for additional strength. The arch is reinforced with 3/16x1-in. steel bands, placed transversely, 12 in. apart on centers and 2 in. from the intrados of the arch. These bands are each in three pieces, a piece on each side extending from 15 in. below to 6 in. above the springing line of the arch, with a piece in the arch adjoining the two side pieces. The three pieces of each band are joined together with cotter pins and were assembled as the sewer was built.

The detail methods of handling the construction and of building the forms were described in the previous article and are briefly as follows: The portion of the sewer built in 1906 was in a trench with an average depth of 18 ft. and an average width of 10.5 ft. About 4 ft. of black soil such as is usually found in a marshy country was encountered first to a depth of 4 ft., and below that was sand and gravel, which was water-bearing for about 5 ft. in the bottom. The trench had to be sheeted throughout, and the water-bearing stratum necessitated the provision of a sub-drain and the use of a pump during the construction. The first 2 or 3 ft. of the top material was either cast out, or plowed and scraped. The remainder of the excavation was handled with a Potter trenching machine. About 200 ft. of trench was kept open at a time, material being taken from in front and deposited in the rear of the concrete work.

Second class and culled pipe were used for the sub-drain, the invert of which is 30 in. below the invert of the sewer. The joints between these pipes were loosely calked with tufts of sod to hold back the fine sand and the whole was covered with medium-size clean gravel. The sub-drain emptied into a sump 18 in. below its invert at the lower end of the new work, a 6-in. rotary pump in this sump discharging the water over a dam into the completed portion of the sewer. Following this method it was possible to put the concrete in on a dry bottom. The invert plastering was done after the forms were removed, and while this plaster was being applied and until it was set it was found necessary to keep the pump in operation to prevent the water forcing its way in, thus causing the mortar to slough off, leaving the bottom rough and the sides to some extent porous.

All the concrete was made in a Smith mixer set up on trucks at the side of the work. It was made as wet as it could be handled conveniently and was moved from the mixer to place in inclined chutes.

The following are the detailed costs per foot of this sewer: Concrete in the sewer barrel, $2.10; steel reinforcement, in place, 30 cents, the steel costing $0.0437 a pound in shape; setting forms and templates, 35 cents; striking and removing forms, 45 cents; plastering invert, 38 cents; sub-drain pipe, in place, 68 cents; handling water, 45 cents; excavation and back filling, $2.80; setting and pulling curbing, $1.04; tools and general expenses, 50 cents; total cost per foot, $9.

Cement cost $1.50 per bbl.; sand, $0.90 per cu. yd.; gravel, $0.90 per cu. yd. The item of handling water included the fuel, housing and rental of the pumping engine, wages of the engineer, and the sinking and subsequent filling of two sump holes for the pump. The labor prices for a 10-hour day were as follows: Engineer for trench machine, $3; fireman for same, $1.65; common labor, $1.85. engineer at pump, $2; sub-foreman, $2.50; carpenters, $2.50. The sewer was built under a contract with Messrs. Hoben & Roach, one of whom superintended the construction.

The sewer was designed and built under the direction of Mr. A. J. Hammond, city engineer, of South Bend.

THE EFFECT OF ALTITUDE ON COMBUSTION is discussed at length by Mr. C. M. Palmer in "Power." Although the difference in number of B.Th.U. required to evaporate water at sea level and at 7,500 ft. elevation appears to be simply in proportion to the difference of pressures at the two levels, the conditions of combustion require a considerable increase in the amount of fuel at the higher level. The temperature is proportional to the product of the concentration (a) of the oxygen in the air, and (f) the concentration of the fuel in the charge. If both are considered as unity $af = 1$. If $y =$ the weight of oxygen in unit volume of air at sea level, and yx is the pressure in cm. of mercury, then $y = 0.01315\ x$, and by assigning any desired value to x, the corresponding amount of oxygen in the air at that level is obtained as compared with that at sea level. This value of y can then be substituted for a in the equation above. From these equations the author shows that a furnace working at 7,500 ft. elevation will use 28 per cent. more fuel than one at sea level, all other working conditions being assumed to be the same in both cases.

Some Details of Concrete Construction.

A paper read before the Western Society of Engineers by L. J. Hotchkiss.

In concrete construction more perhaps than in any other, development has far outrun the literature of the art. In reinforced work this is especially apparent, as new applications of this form of construction are so numerous that the ingenuity of the engineer is heavily taxed to provide economical methods of construction, and to see that no consideration of safety or good practice is overlooked. The author proposes to describe some of the methods used on recent work in the hope that the discussion may develop other methods of greater value.

In considering some of the features of concrete construction as carried out by the railroads, reference may be made to the track elevation work now going on in Chicago, in which a large amount of concrete, both plain and reinforced, is being used. In Fig. 1 is shown a typical cross section of the retaining walls being built by the Chicago, Burlington & Quincy Ry. This wall is but little more difficult to construct than a plain one, while the yardage is much less. Except where inclined walls are required for approaches to team tracks, the tops of all walls are at the same elevation, and that part of the cross section above the angle in the back of the wall is retained throughout. Changes in height are made entirely below this angle, the elevation of the footing varying in horizontal steps, thus maintaining the bearing surface normal to the direction of pressure, and facilitating the use of sectional forms, which will be illustrated later. Plain abutments are used in connection with these retaining walls, the footings having a reinforced projection in front to increase the bearing area. This type of abutments was used in preference to reinforced ones, because of difficulties in construction the latter. All footings and the lower part of the abutments were built before any of the tracks were raised, the abutments being completed after the tracks had been elevated on temporary bridges. Reinforced abutments could not have been readily built in this manner.

Each track is to be carried over the subways on four spans of reinforced concrete deck girders, resting on the abutments and on three lines of steel columns and cross girders. The sidewalk girders are 10 ft. 9 in. long and 17 in. thick, and the street girders are 24 ft. 3 in. long and 33 in. thick. The girders are built in sections about 7 ft. wide, two sections being required for each track. There are to be 15 subways and the number of tracks carried will vary from 6 at Blue Island Ave. to 42 at Robey St. Such a large number of girders, or "slabs" as they are called on the work, is required that a special yard was established for their manufacture.

This road is also doing large amount of concrete construction outside of Chicago. Rectangular boxes form an important part of it. A cross section of one of them with the forms in place is shown in Fig. 2. They are used for culverts, cattle passes and subways, and are built to any length and under any embankment. They range in size from single 4 x 4 ft. to double 20 x 20 ft. and triple 16 x 20 ft. boxes. They have many advantages over arches, being far more simple both in design and construction. The form work is of the plainest kind. No piles are needed under them, and they may be placed on any kind of ground material, whether soft mud, quicksand or gravel. Where a rock foundation is available an arch is the cheaper form of construction. But in any location requiring piles the comparison is the other way. The massive abutments required to give stability to an arch, cover an area well outside the clear opening, and place upon the piles the weight of a mass of earth which, if a box culvert were used, would fall entirely outside the structure. The pits to be excavated for the arch exceed in breadth, depth and yardage, what is required for a rectangular box. Where the material to be excavated is sand or soft mud, the single item of depth of foundation required, will make a large difference in the cost of sheeting and pumping. Where a structure is to be built under a track in service, the temporary opening required for a box culvert is but a few feet more than the clear span of the completed work, while for an arch the length of the temporary bridge must be increased to clear the abutments. Because of this difference a small box culvert can often be built between the bents of an existing pile bridge without in any way disturbing the latter, while if an arch were used one or more bents would have to be replaced by a temporary steel bridge. A large number of these boxes have been built by the Chicago, Burlington & Quincy Ry., and not one of them has failed to give satisfaction.

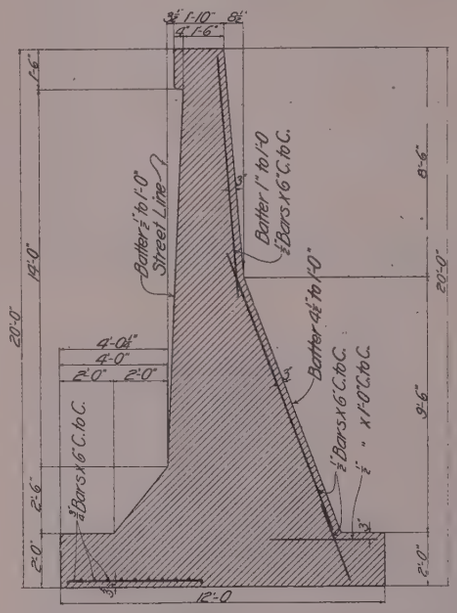


Fig. 1, Cross-Section of Retaining Wall.

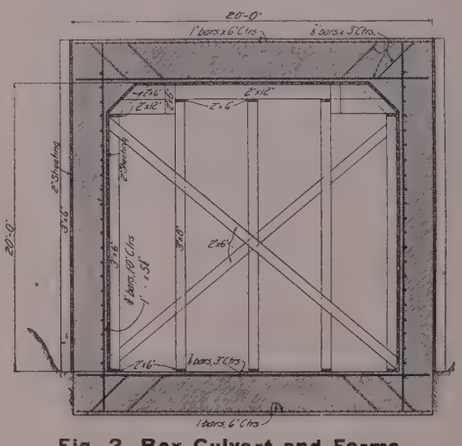


Fig. 2, Box Culvert and Forms.

In Fig. 3 are shown the forms used on the retaining walls previously referred to. They are a combination of continuous and sectional forms; the sectional part consisting of studs, coping and bottom forms for the face and sectional forms for the back of the wall. Ordinarily sheeting is used between the coping and bottom forms, the back forming being entirely sectional. All sections are made in templates and delivered on the work in units, as shown in the figure. No attempt was made to use sectional forms on the face of the wall, except as mentioned, because the sections become battered and warped with use, do not fit closely together, and leave the wall rough when they are removed.

In Fig. 4 is shown the method of bracing and tying down the forms. The cross section of the wall is such that the wet gravel concrete used had a tendency to lift the forms off the footing. This did occur in one case, causing considerable trouble. The plan shown in the illustration was then adopted, the bars being placed in the footing and the forms tied to them with wires. In building such walls it is difficult to keep them in perfect alignment. Small variations in the face of the wall are not noticeable, but any deflection of the coping shows at a glance. The method of bracing the coping form shown in Fig. 4 furnished an easy and effective way of lining up that form.

In Fig. 5 are shown the forms used for building the deck girders or slabs for the subways, this form being for one of the street slabs. These slabs are very heavy, weighing 35 tons each, and it was necessary that a good foundation be found for them. At Morton Park a large bed of cinders several feet deep was available. This was leveled off and the forms built there, the timbers supporting the forms being carefully tamped and leveled. Each side and each end form was complete in itself. They were set to templates laid on the floor of the box, as only ¼ in. clearance is allowed for each slab; they were used many times. One hundred floors were provided, and when they were all filled with concrete the slabs first built, were sufficiently seasoned to be piled up and thus permit using the floors again.

In Fig. 6 is shown one of the abutments which the Chicago, Burlington & Quincy Ry. built for a special subway at 48th Ave., Hawthorne. After the footing had been constructed, boxes having three sides and a roof were built between each pair of buttresses. These boxes formed back forms for the curtain wall, side forms for the buttresses and bottom forms for the bridge seats. They were very expensive on the first abutment, as all sheeting was placed horizontally and cut carefully to fit. On the second abutment most of the sheeting was placed vertically, and as little cutting as possible done, the result being a large saving in the cost of form work.

In fastening wall forms together the use of bolts or rods instead of wires increases the efficiency of the forms, and does not increase the cost. On the work described here pieces of scrap pipe were cut to fit loosely between the forms and the rods passed through them and removed after completion of the work. The ends of the pipes were stuffed with waste to keep the grout from filling them. Small blocks of wood placed between the form and the ends of the pipes have also been used for the same purpose, the blocks being later removed and the holes filled with mortar. Neither plan is entirely effective, and the pipes sometimes fill with grout, making it difficult to pull out the rods. The rods and pipes cost but little more than wire and the labor of placing them is materially less. The wires always stretch a certain amount, and frequently break, permitting the forms to spread. If bolts are used the forms can be filled with wet concrete to a depth of 15 or 20 ft. without danger. Forms should be coated with some substance to close the pores in the wood. The finish of the concrete is improved and the lumber is left in better shape to use again, as less concrete sticks to it. Soft soap thinned with water and applied with a whitewash brush or a broom works well for this purpose. Some drilling and lubricating compounds and black oil have also been used. They are greasy and do not dry quickly, and in this respect are better than soap.

The careful placing of bars is one of the most important features of reinforced concrete work, and one which is too frequently neglected because of the expense of doing it right. A method of

placing them in the inverts of boxes is shown in Fig. 7, which is both simple and effective. It applies equally well to wall footings. The stakes can be of any convenient size, 2 x 2 in. being sufficient. Their spacing depends upon the weight of bars to be carried. It need not be less than 6 ft. centers and can often be more. The longitudinal bars are secured to the stakes by wire nails bent over the bars. The bars are tied together at their intersections with small, soft wire, such as stove pipe wire. If a convenient clip applicable to all sizes of bars could be devised, it would be a welcome substitute for the wires, as this part of the work is slow and expensive, and must be thoroughly done, where the concrete is placed in large batches, especially if it is dropped several feet into the pit. Where a wet gravel concrete is used, the need of secure fastening for the bars is particularly great. Such a concrete flows easily and if bars are merely laid in place they will be swept aside as though they were chips. The vertical bars in walls may be carried on longitudinal timbers supported over the footing. They can be fastened with wire nails, and ordinarily only one line of supports is required, as the bars can be thrust into the concrete after the pit is partly filled, thus making the concrete assist in holding them. The longitudinal bars should be wired to the vertical ones if accurate spacing is desired. In thin walls this must be done before the forms are completed, because of the limited working space. In the roofs of boxes the bars can be supported in a manner similar to that used in inverts, the iron supports shown in Fig. 8 replacing the stakes. Small blocks of concrete cast with notches to retain the bars are also used for this purpose..

For general use concrete mixed wet is better than a dry mixture. If good gravel is obtainable it is to be preferred to crushed stone. A wet gravel concrete can be handled much more cheaply than stone concrete, and gives as good results. It dumps easily from cars or buckets, can be placed in the forms with little labor, and requires no tamping. A derrick can serve a larger area from one position with such a mixture than if dry concrete is used, for the wet gravel concrete will flow in chutes placed at an angle so flat that dry concrete or even a wet stone concrete will not move.

In the construction of walls it is best to avoid longitudinal joints wherever possible. If a section of wall is partially filled, and the concrete allowed to stand for some time, it is difficult to remove all the laitance, and in thin reinforced walls this work is difficult at any time. If it is not thoroughly done, an unsightly joint results, and one through which seepage will occur, with consequent discoloration of the surface. Where the nature of the work will permit, vertical bulkheads can be built at convenient intervals, and the space between filled without stopping. More bolts must be used to tie the forms together than if the concrete were placed in layers, but otherwise the forms need not be heavier than would ordinarily be used. The concrete can be placed more economically, as less moving of equipment is required. The vertical joints are less conspicuous than horizontal ones. In plain walls they also serve as construction joints, and if a triangular molding is placed in them the resulting grooves relieve the monotony of the surface and conceal the opening of the joints from contraction of the wall. The use of vertical tenons in these joints is of little value, as the tenons quickly crack in the plane of the joints. A small percentage of longitudinal reinforcement will do the work of the tenons and also prevent contraction cracks.

Similarly, in building the inverts and roofs of boxes and footings for retaining walls, vertical bulkheads should be filled continuously. When quick-setting cement is used in hot weather, care must be taken that these sections are not too long. In one case observed last summer, a section of the roof of box equal to a day's work had been bulkheaded off. One end of the section was filled half full, and while the other end was being filled the concrete first placed became so hard a man could walk on it without making an impression This made a joint in a horizontal plane, which should not be permitted in any beam.

Occasions will arise, however, where a longitudinal joint in a wall is necessary, and where this is the case the thorough cleaning of the concrete is often neglected. The laitance is not all removed and dirt, shavings and sawdust are permitted to remain in the forms. This work cannot be left entirely to laborers but must have efficient supervision and inspection. The surface of the concrete should be scrubbed with wire brushes and water until every stone shows clearly, and the water used in the scrubbing should be flushed off and not left standing in the forms with the laitance in suspension, to be deposited on the concrete again as soon as the scrubbing gang has gone. Both time and expense can be saved if the cleaning is done before the concrete becomes hard. It can be done with shovels and a small amount of washing instead of the protracted scrubbing necessary later. The bond obtained in even the most carefully cleaned joint is of uncertain strength, and if the cleaning is poorly done, there is no bond at all.

For small jobs where it does not pay to install a power machine a hand power mixer mounted on a frame carried on two large wheels is used by the C., B. & Q. Ry. This machine is turned by a crank driving a sprocket chain. It is charged at the material piles, turned and hauled to the work to be discharged into the forms, and is fairly satisfactory. It requires much turning and the men are apt to become careless and dump it before mixing is completed, but, with careful supervision, good work can be secured. The mixer is at least as efficient as hand work, is more convenient and easier on the men.

On many railroad jobs local conditions are such that a power mixer of large capacity cannot be worked to its limit. Difficulties in supplying it with material, or in taking away the concrete, reduce its output to that of a much smaller machine. The latter is cheaper in first cost, in installation and in operation. On the other hand, if the yardage is sufficient to justify the installation of equipment for handling the output of a large mixer, it is better than a small one, for the increase in plant charges is not in proportion to the increase in amount of concrete handled. Again it may occur on a comparatively small job that the concrete must be taken a long distance from the mixer, that a large batch can be moved as quickly and easily as a small one and the time consumed in doing it is sufficient for the charging and turning of a large machine before the concrete car or bucket returns. Here the large mixer, while it may stand idle part of the time, is still economical. The use of continuous mixers is undesirable unless there be used with them a reliable measuring and feeding device. Without such a device the concrete is lacking in uniformity both as to proportion and consistency. One outfit, observed recently on street paving, serves to illustrate this. Stone was piled on one side of the machine and sand on the other. Three men shovelled sand into it while six others supplied it with stone and yet another put in cement from time to time. The concrete as dumped on the ground was sometimes wet and sometimes dry. Part of it was thoroughly mixed and part was but slightly mixed. This is doubtless an extreme case, but similar ones are numerous and show the lack of reliability of such machines when used without proper appliance for proportioning the mixture.

The varying requirements in the way of equipment are well shown in the construction of some of the concrete boxes to which reference has been made. They are often located under a high, short

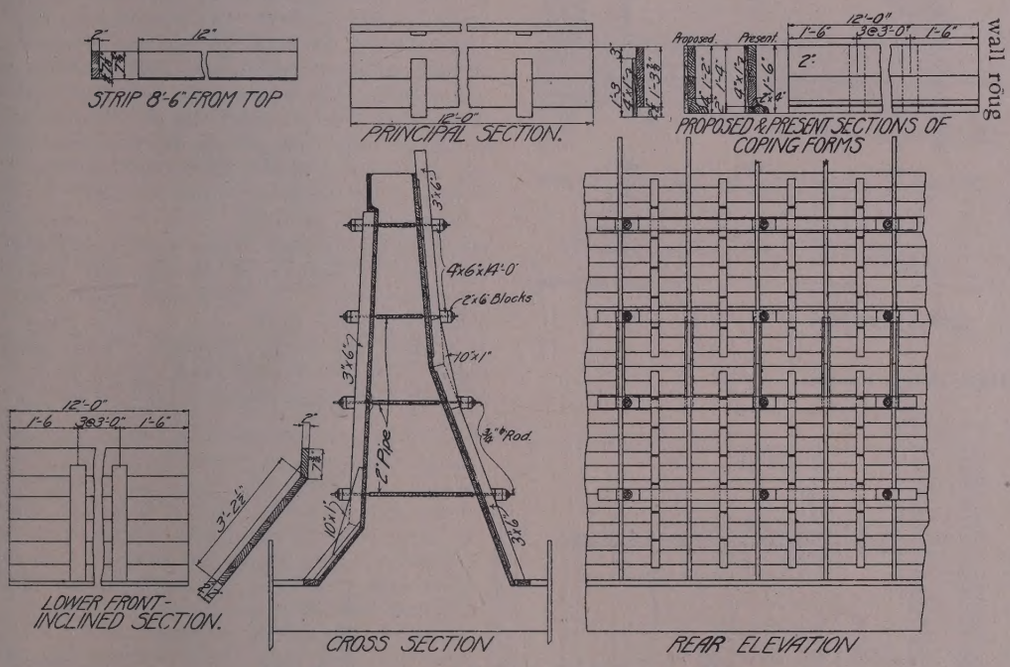


Fig. 3. Sectional Forms for Retaining Wall.

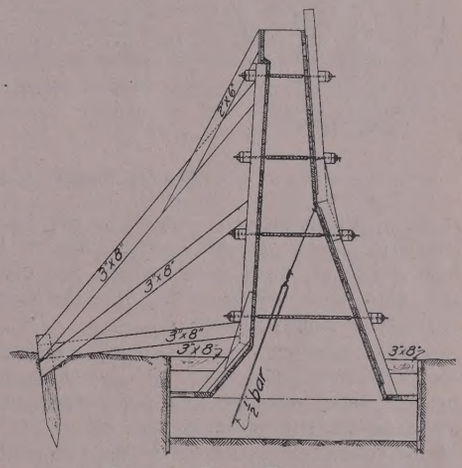
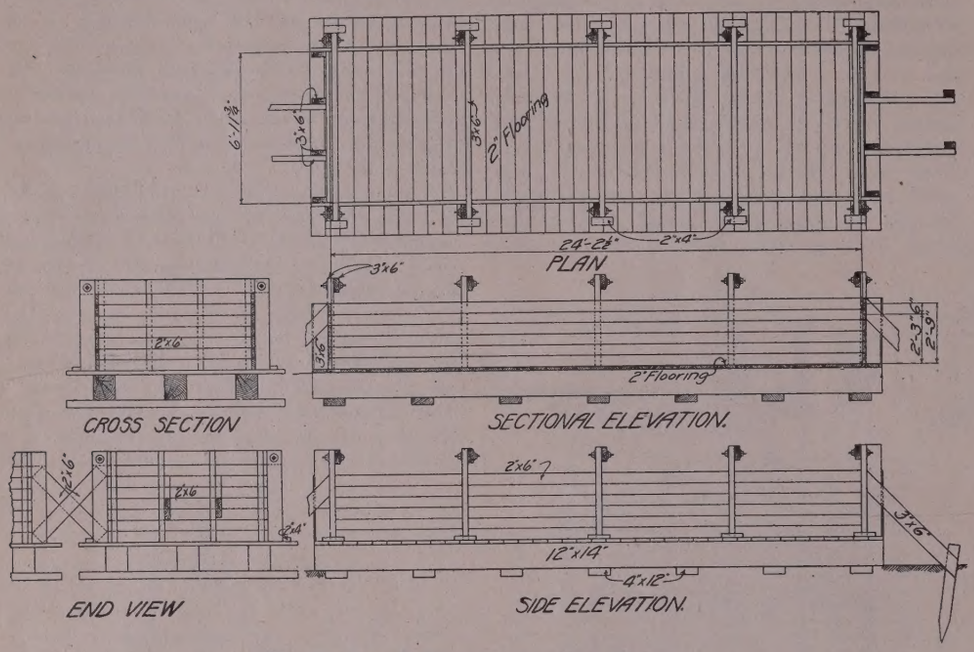


Fig. 4. Form Bracing.

trestle at the end of which the material must be unloaded on the side of the embankment. The conditions at such a job recently built permitted the installation of a convenient plant. Old bridge timbers were available for building a platform along each side of the embankment about 8 ft. below the top of ties. A track for a material car was built on each platform before gravel was unloaded on it. Each track extended out over a mixer located on the end of the embankment and bottom dump cars, operated by hand, discharged directly into the mixers. The latter discharged into concrete cars running on a slightly inclined track, up which they were pulled by the mixer engine to a point over the concrete "box" to be built where the loads were dropped into other cars, on a track running on the forms the length of the "box" supported above it.



Ffg. 5. TracK Elevation--Slab Forms.

Another long box culvert, also just completed, required a very different lay-out It was located in a flat valley traversed by a meandering creek and about 600 ft. from the present track. Gravel was unloaded from this track on the side of the embankment at the foot of which a large platform had been built, with its outer edge raised enough to clear two tracks carrying 5-yd. side dump cars. Gravel was loaded into these cars through holes in the platform by means of teams and drag scrapers, and the cars drawn to a point near the work with a cable operated by the mixer engine. The gravel was dumped at the foot of an inclined platform leading to a hopper elevated sufficient to let a 1½-cu. yd. bottom dump car pass under it. A team, a cable, and a drag scraper, delivered the gravel through the hopper into the material car, cement being put in by hand at the same time. The mixer engine pulled the material car up an inclined track from which the mixer was charged. The concrete car into which the mixer discharged was drawn up a steep incline leading to a track which extended the full length of the culvert and was supported above it on the forms.

At Galesburg a doublt 20x20-ft. cement box to carry a street under a new yard was built entirely below the level of the natural ground. For this work an old steam shovel was available. It was transformed into a derrick with a 40-ft. boom and operated on a track parallel to the work. The mixer discharged concrete into cylindrical bottom-dump buckets seated on push cars. The latter were pushed by hand to where the derrick could reach them and the buckets swung out over the box to drop their loads onto chutes. The concrete was thus placed in any desired part of the work with but little hand labor.

The work on the Chicago track elevation required outfits easily moved from place to place and several somewhat similar schemes have been used. The cement car is located ahead of the gravel cars and overhanging its forward end carries two hoppers 1½ cu. yd. capacity each. The two hoppers enable the wheel-barrow men to work continuously, the material car being charged alternately from either hopper. The material car is pulled up the incline to the charging platform by the mixer engine. The mixer is arranged to discharge into a chute, a bucket or a concrete car.

In an outfit used on the Chicago & Northwestern Ry. the material is brought forward by wheelbarrows on runways laid on top of the cars and dumped directly into the mixer. By means of a hopper with a gate the concrete was discharged into wheel-barrows when desired.

In the equipment used by the contractor on the Illinois Central retaining walls at Grant Park a light derrick traveled back and forth on a track laid on two flat cars thus distributing the concrete uniformly over a considerable section of wall.

All of these outfits have one serious fault, the use of wheel-barrows for bringing the material to the mixer. The wheel-barrows are so high above the bottom of the car that loading them is a matter of difficulty and the wheelers and shovelers are entirely unreliable. The contractor on the Chicago Junction Ry. has gotten up a scheme which does away with the wheel-barrows, and is a long step in the right direction. Two narrow gauge tracks are carried over the tops of the material cars, and connecting on the mixer car into a single track which extends over a hopper above and back of the mixer. Two long, low steel dump cars of about 1 cu. yd. capacity are operated, one on each track. A cable from the mixer engine pulls a car up to the hopper where it is dumped and automatically returns to its normal position. The track on the mixer car is inclined and gives the empty car sufficient momentum to return it for reloading. This car seems to be open to one objection.. As it travels along the outer edge of the material cars it can only be loaded from one side. Not more than four men can shovel into it at a time. The capacity of the plant is therefore limited to the output of eight shovelers, but the contractor says that with it he was able to handle at least as much concrete as local conditions would permit him to place, or with any other outfit. Even if no increase in output or reduction in expense results, the decrease in the number of men required is a distinct improvement, especially in view of the prevailing scarcity of labor.

Spading the face of the concrete to secure a finish gives good result if the work is carefully done and no washing of the wall with grout should be required. In the writer's opinion this method is superior to any form of mortar facing. It is easier and cheaper, is equally effective and the face does not check or crack. A mortar finish does both, in the course of time, permitting seepage and discoloration of the face of the concrete.

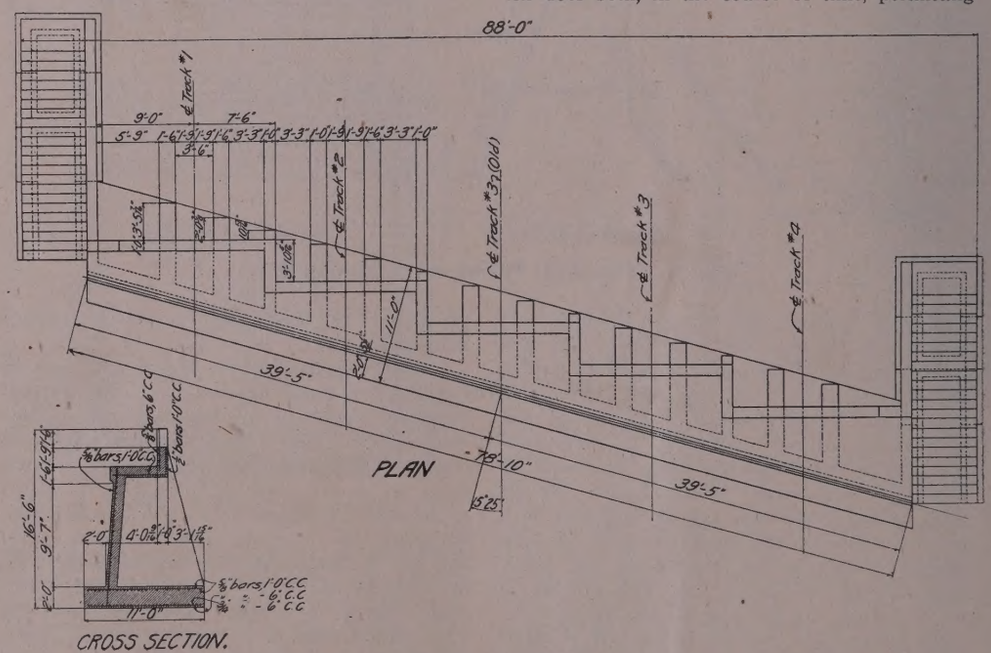


Fig. 6. East Abutment of Burlington Subway at 48th Ave. Hawthorne.

For doing the spading, a common garden hoe, straightened out until the blade is nearly in line with the handle, is an excellent tool. For reinforced work where the spading must be done in a space of 2 or 3 in., this tool is particularly useful. On high reinforced walls which must be spaded from the top, long handles are required. It is well to have these tools with different lengths of handle, the shorter ones being used near the top. Reinforced walls 20 ft. high have been fin-

ished in this manner and no other treatment was needed.

It is often necessary to build walls with the top sloping steeply, as in the case of wing walls for abutments and culverts. Where wet concrete is used covered forms must be built for such walls, to keep the concrete from flowing out at the bottom of the slope. The cover boards can be removed as soon as the concrete has set so it will stand, and then the surface finished with a trowel. In hot weather this work can sometimes be commenced at the bottom of the slope while concrete is still being placed at the top. In chilly weather the wall can stand over night and the cover boards be removed in the morning and the surface finished.

The Chicago, Burlington & Quincy Ry. specifications require that exposed edges be finished to a curve of small radius. For this purpose cove molding is often used. It works well for vertical edges and for the lower edges of horizontal beams. If used for the tops of walls the concrete in setting shrinks away from the molding leaving a rough surface. A better finish can be obtained by working the green concrete with a curved edging tool such as used in sidewalk construction.

The amount of concrete placed during the winter months is constantly increasing and this work can be done with entire safety, if proper care be taken in heating the materials and keeping the concrete warm in the forms. For thin reinforced walls, it is not safe to rely on heating the water alone or even the water and sand, but the stone also must be heated and the concrete when it goes into the forms should be steaming hot. For mass walls the stone need not be heated except in cold weather. Where concrete is mixed in small quantities the water can be heated by a wood fire, and if a wood fire be kept burning over night on top of the piles of stone and sand a considerable quantity can be heated. The fire can be kept going during the day and moved back on the pile as the heated material is used. This plan requires a quantity of fuel which in most cases is prohibitive and is not sufficient to supply a power mixer. For general use steam is far better. A convenient method is to build a long wooden box 8 or 10 in. square, with numerous holes bored in its sides. This is laid on the ground, connected with a steam pipe and covered with sand, stone or gravel. The steam escaping through the holes in the box, will heat over night, a pile of sand, or sand and gravel 8 or 10 ft. high. Perforated pipes can be substituted for boxes. Material can be heated more rapidly if the steam be allowed to escape in the pile than if it is confined in pipes which are not perforated. Crushed stone requires much more heat than sand or sand and gravel mixed, because of the greater volume of air spaces. In many cases material which has already been unloaded must be heated. The expense of putting steam boxes or pipes under it is considerable. To avoid this one or more steam jets may be used, the end of the jet pipe being pushed several feet into the pile of material. If the jets are connected up with steam hose they are easily moved from place to place. It is difficult to heat stone in this way except in moderate weather.

The writer recently tried with a single jet to heat a pile of stone when the thermometer showed 25° below zero, and was unable to supply a single small gang mixing by hand, although another jet heated an abundance of sand. Concrete cannot be placed in such weather except at an expense for heating which is only justified in extreme cases.

On mass work and at such temperatures as are met with in this latitude it is not usually necessary to protect concrete which has been placed hot, except in the top of the form. This can be done by covering the top of the form with canvas and running a jet of steam under it. If canvas is not available, boards and straw or manure answer the purpose. If heat is kept on for 36 hours after completion, this is sufficient, except in unusually cold weather. The above treatment is all that is required for reinforced retaining walls of ordinary height. But where box culverts or arches carrying heavy loads must be placed in service as soon as possible, the only safe way is to keep the main part of the structure warm until the concrete is thoroughly hardened. Forms for these structures can be closed at the ends and stoves or salamanders kept going inside, or steam heat may be used. The outside may be covered with canvas or boards, and straw and steam jets run underneath. After the concrete has set enough to permit the removal of the outer forms of box culverts, fires may be built near the side walls and the concrete seasoned rapidly. Where structures need not be loaded until after the arrival of warm weather, heat may be applied for 36 hours, and the centering left in place until the concrete has hardened. Careful inspection of wintter concrete should be made before loads are applied. In this connection it may be noted that concrete which has been partly seasoned and then frozen, closely resembles thoroughly seasoned concrete. Pieces broken off with a smooth fracture through all the stones and showing no frost marks, yet when thawed out, can be broken with the hands.

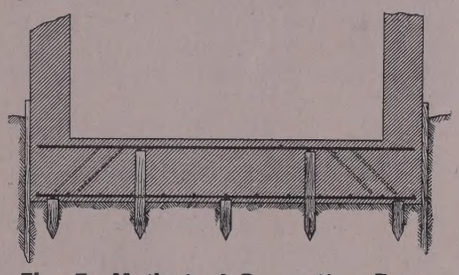


Fig. 7. Method of Supporting Bars.

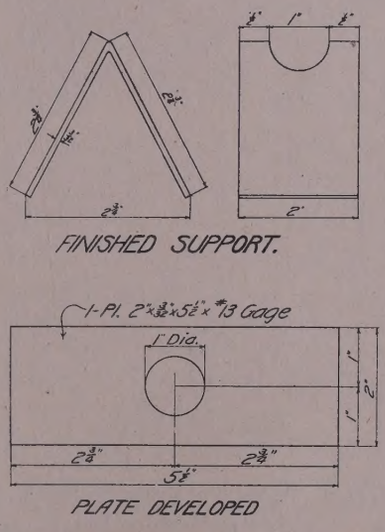


Fig. 8. Corrugated Bar Support.

In conclusion, it cannot be too strongly urged that all details of concrete work be carefully done, as the simplicity of most of the operations leads to carelessness.

A New Sewage Filtering Material has been developed by the Ligno-Carbon Co., Heathfield, Newton Abbot, South Devon, England, with the assistance of Mr. W. B. G. Bennett, well known among American civil engineers on account of his long service as city engineer of Southampton. The material is an oxidizing agent like the "porous carbon" used some years ago in sewage precipitation in England. It has been employed at Lyndhurst and elsewhere with results that are reported in the British technical papers to be satisfactory.

Book Notes.

Two books which are essentially class books for teaching purposes are "Problems in Surveying, Railroad Surveying and Geodesy," by Messrs. H. C. Ives and H. E. Hilts, and "Elements of Mechanical Drawing," by Prof. A. A. Titsworth, published at $1.50 and $1.25, respectively, by John Wiley & Sons, New York. The first affords an interesting proof of the fact that our technical schools are no longer endeavoring to turn out expert surveyors, but are striving rather to teach how such work is done, so that in case a graduate is called upon to undertake it the dexterity that comes only with practice is all he is required to learn. It is a waste of time for a young man in a high-class engineering college to endeavor to acquire facility in field work which he may never be called upon to do, and if he is so employed, can learn much more rapidly under a plain-spoken chief of party than when he is surrounded by classmates under the direction of an instructor almost as young as himself. The book also indicates that the general course in surveying at the University of Pennsylvania is a well-balanced one. The second book gives the course in elementary mechanical drawing adopted at Rutgers College. The first part is intended to acquaint the beginner with the use of instruments and the second part is a collection of problems in descriptive geometry. The directions for the use of instruments and for lettering are good and the problems seem calculated to teach this kind of drawing in a rational manner. There has been a lot of nonsense published about elementary drawing and in some schools there was a tendency formerly to lay more stress on the methods of sharpening pencils than on neat and accurate drawing. Nothing of this pedantic character is apparent in Prof. Titsworth's book.

An unusually interesting book under the rather misleading title of "Modern Practical Carpentry" has been written by Mr. George Ellis, vice-president of the Incorporated British Institute of Certified Carpenters. Although it is called a description of modern methods of carpentry its value to American readers is largely in the information and illustrations it contains regarding the achievements of woodworkers of the last century and even earlier periods. On account of its excellent selection of examples of such work the volume will be found a valuable addition to any library aiming to be fairly complete on architectural and engineering subjects. The book opens with a description of the tools used by carpenters and the methods of using them, and the practical experience of the author in carpentry is indicated by the excellent advice he gives. The various types of joints and fastenings employed in carpentry are next explained and the methods of laying out the most important are stated. The different kinds of beams and trusses, partitions and floors constructed of word are taken up in three chapters, and then comes an unusually good one on roofs. It explains the general framing of large and small roofs and many of the illustrations show the construction adopted in notable churches. It also gives a large amount of information concerning the framing of minor details of roof construction and explains the methods of laying out the more difficult framing details. The design of scaffolds, staging and traveling derrick towers is described, and there are some notes concerning the use of round poles for scaffold posts which will probably interest American builders who are having trouble in securing sawed timber for such work at a reasonable price. Attention is also called to the information given in the book regarding flying scaffolds supported from the work as it rises and not from the ground. The description of temporary stages and grandstands in the

next chapter indicates that such work is done in a much better fashion in England than here, if the illustrations are at all typical. Up to this point the book relates mainly to architectural carpentry, but engineering work is not neglected and there are a number of chapters devoted exclusively to it. The first of these describes the centering used on arches, domes, vaults and other works, the illustrations including a reproduction of an old engraving by Piranesi of the centers for the Blackfriars bridge at London. The second is an explanation of the timbering done in trenches and tunnels, and the third is an account of wooden bridges. In this last chapter are descriptions of a great variety of structures, from the temporary wooden bridge recently employed in the reconstruction of the Vauxhall bridge at London to some of the rather unusual structures built fifty years or more ago. Although there is a section devoted to American timber bridges, those described have long since been replaced and there is no mention of the famous Howe type which was used on most of the railroads of the country at one time or another. There are also chapters on shoring and underpinning, on cofferdams and caissons, on pile foundations, and on piers and wharves. In all of these engineering chapters the author's aim has apparently been to describe how the workmen carry out the work rather than to explain the technical details of design. Two chapters on half-timbered and full-timbered houses will appeal particularly to architects who are interested in seeing detail drawings of the framing in some typical English examples of such construction, and there is a chapter on gates which will also interest that class of readers. In addition to the subjects mentioned the principles of trussing and framing, the causes of failure in wood structures, the properties of wood and the use of the carpenter's square are treated at length, and there is an excellent glossary. (New York, Industrial Publication Co., $5.)

During the nine years that Mr. Lester G. French was editor of "Machinery" he had an exceptional opportunity to collect information concerning the steam turbine, which he has worked over into a comprehensive treatise bearing the title, "Steam Turbines, Practice and Theory." It opens with a chapter explaining concisely the fundamental principles of these prime movers, which is followed by one tracing their development down to the time they became a commercial success. At the end of this chapter there are some interesting notes concerning the frequent recurrence in patents of features which tend to make an unsuccessful rather than a successful machine; people who have turbine patents presented to them for investment will find these notes, although short, a useful guide in avoiding wasting their money on inventions doomed to failure. Two chapters are devoted to the De Laval, Rateau, Riedler-Stumpf, Zoelly, Richards, Levin and Kerr types of simple impulse turbines, and two more chapters are given to the compound impulse types of Rateau, Zoelly, Holzwarth, Curtis, Riedler-Stumpf and the General Electric Co. of Germany. The reaction turbine of the Parsons type, as made by the Westinghouse Machine Co., Brown, Boveri & Co., and the Allis Chalmers Co., is the subject of the seventh chapter, and the eighth is devoted to the Crocker-Warren, Union, Sulzer and Lindmark machines, the Rateau steam accumulator system and the low-pressure Curtis turbine. The portion of the book which may be called descriptive closes with the eighth chapter, and the next section contains two chapters on the performance of reciprocating engines and turbines, which will enable the reader to form a fair comparative estimate of what the two types accomplish under running conditions. In the next six chapters, Mr. French describes the properties of steam and the temperature-entropy diagram, reviews the more important experiments on the flow of steam through orifices and nozzles, and discusses the adiabatic flow of steam and the design of turbine vanes. The mathematical treatment has been simplified as much as possible and examples have been worked out to illustrate the use of the more important formulas. There is an interesting discussion of the phenomena of rapidly rotating bodies and the method of balancing disks is explained. Notes on efficiency and design, on the commercial aspect of the turbine and its care and management, on condensing apparatus for high vacuum, and on status of the marine turbine round out the book satisfactorily. Taken as a whole it is a work which will probably answer the requirements of all technically educated readers who desire a comprehensive review of the turbine field down to the present time, without any of the involved mathematical analyses which are necessary in a detailed study of this important prime mover. (Brattleboro, Vt., The Technical Press, $3.)

Letters to the Editor.

CONCRETE TANKS FOR OIL.

SIR: Referring to your issue of Feb. 9, 1907, page 168, in which you call for information regarding concrete tanks which have held oil for any length of time, and results thereof, I beg to call attention to your issue of Jan. 5, page 9 first column, in which a test tank of 1:2:4 concrete was made by the El Paso & Southwestern R. R.

Your article states that "this tank was filled with oil and at the end of nine months the level had dropped 5/8 in. due probably to evaporation. The oil penetrated and discolored the concrete less than 1½ in., and the tank was not apparently injured thereby."

Although a few more details, such as time of setting of concrete before coming in contact with oil, size of tank, thickness of shell, etc., might be serviceable, could they be procured, I trust the above will be of some value.

Respectfully yours,

BOSTON, Feb. 21. JOS. F. WILBER.

COST OF WATER FILTRATION IN BROOKLYN.

SIR: I see in your issue of Feb. 16, 1907, on page 171, a brief article giving the comparison of cost of the mechanical and slow sand filters in our Department. I would like to state that while there is no question as to the slow sand filtration being better than the mechanical for the local conditions on Long Island, the comparison of cost data, as given in this case, is apt to be misleading. In the first place, the mechanical filters are of very small capacity, the one 3,000,000 and the other 5,000,000 gal. per day, and owing to the shortage of supply one of these filters, the larger, was operated at 80 per cent. of its capacity, and the other at 63 per cent.

The force account, which makes up a large amount of the cost, is very large, owing to the fact that city laborers can be employed for only eight hours each day. The force account for the smaller filter is the same as for the larger, and will explain the relatively large cost of the smaller plant. The force account would be the same for a plant double the capacity of the larger filter, and the force account on the mechanical filters is charged against them even when not in operation, whereas the labor on the slow sand filters is only the actual cost of labor used, the men being utilized for other purposes the greater part of the time.

As regards the item of first cost, these slow sand filters have another decided advantage, as they were constructed without any concrete or other waterproof lining, and owing to conditions which are strictly local were designed for an inflow of ground water. No regulating device for rate other than flash boards on the inlet were provided, and the entire construction is of the crudest type. For our local conditions this type of slow sand filter is not only the cheaper but also gives better results than mechanical filters, whereas under under conditions a construction of this type would probably be impossible.

I am sending you these facts simply to prevent any misunderstanding of the figures given in the report, as they do not form a fair comparison, under ordinary circumstances, between mechanical and slow sand filtration.. I am also sending you herewith some detailed data which were prepared by Mr. Coffin, who is our inspector at the filter plants.

Trusting that this matter will be of interest to you, I am,

Yours very truly,

B. M. WAGNER,
Assistant Engineer.

Operation of Baisley's Filter Plant, 1905.—The rated capacity of the plant is 5,000,000 gal. per day.

The average gross pumpage for the year was 4,225,000 gal. daily; the net filtered water (gross pumpage less wash and waste), was 3,932,900 gal.

The average cost of filtration per million gallons is determined from the following table:

Variable Charges.		
Inspection	$484.80	7.9%
Operation	4,712.90	76.6%
Laboratory	443.68	7.2%
Repairs	597.78	8.3%
Total	$6,149.16	100.0%

The fixed charges for interest and sinking fund were $3,218.64. The total yearly cost of operation was $9,267.80. The total net filtered water was 1,435,508,460 gal., making the cost of filtration per million gallons, $6.53.

These figures of cost are exclusive of pumpage. Operation charges include the attendance of three men at $2 per day, extra help, alum, soda, cartage, etc. Laboratory charges include labor and supplies. Previous to the month of August the inspector did the laboratory work; since this date a laboratory assistant has been detailed for it. Repairs include labor and materials.

No record is kept of the cost of fuel used in pumping and washing.

The cost of labor is $2,740 per year or $1.91 per million gallons.

The cost of chemicals is $1,972.90 per year, or $1.37 per million gallons.

The cost of supervision is given in the foregoing table under the heading of "Inspection and Laboratory."

The laboratory assistant does the work for four filter plants, the charge to each being proportionate to the number of samples.

Baisley's is one of four filter plants operated by the city under the immediate charge of one inspector, whose time is charged to each plant in proportion to the time spent at each.

Operation of Springfield Filter Plant, 1905.—The capacity of the plant is 3,000,000 gal. per day. The net filtered water was 1,903,045 gal. per day (pumpage less wash and waste). The average cost of filtration was $9.49 per million gallons for 1905. The cost of fuel used in pumping and washing is unknown. The cost of labor was $2,740 per year, or $3.95 per million gallons. The cost of chemicals was $963 per year, or $1.39 per million gallons.